TETRA TECH

March 6, 2015

Mr. James Johnson
On-Scene Coordinator
U.S. Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219

Subject: **Interim Data Summary of AreaRAE Measurements During Ongoing Baseline Off-Site Air Monitoring**
West Lake Landfill Site, Bridgeton, Missouri
CERCLIS ID: MOD079900932
EPA Region 7, START 4, Contract No. EP-S7-13-06, Task Order No. 0058
Task Monitor: James Johnson, On-Scene Coordinator

Dear Mr. Johnson:

Tetra Tech, Inc. is submitting the attached Interim Data Summary Report regarding carbon monoxide, hydrogen sulfide, and sulfur dioxide measurements by RAE Systems, Inc., AreaRAE instruments during ongoing air monitoring at locations off site of the West Lake Landfill site (WLLS) in Bridgeton, Missouri. This monitoring is occurring during a baseline period prior to start of construction of an isolation barrier at WLLS. If you have any questions or comments, please contact me at (816) 412-1775.

Sincerely,

Robert Monnig, PE
START Project Manager

Ted Faile, PG, CHMM
START Program Manager

Enclosures

cc: Debra Dorsey, START Project Officer (cover letter only)

X9025.14.0058.000

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INTERIM DATA SUMMARY OF ONGOING BASELINE OFF-SITE AIR MONITORING FOR CARBON MONOXIDE, HYDROGEN SULFIDE, AND SULFUR DIOXIDE MEASUREMENTS

WEST LAKE LANDFILL SITE
BRIDGETON, MISSOURI
CERCLIS ID: MOD079900932

Superfund Technical Assessment and Response Team (START) 4
Contract No. EP-S7-13-06, Task Order No. 0058

Prepared For:

U.S. Environmental Protection Agency
Region 7
Superfund Division
11201 Renner Blvd.
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March 6, 2015

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1.0 INTRODUCTION

The Tetra Tech, Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) has been tasked by the U.S. Environmental Protection Agency (EPA) to assist with baseline monitoring at off-site locations around the West Lake Landfill site (WLLS) in Bridgeton, Missouri (the Site). The monitoring effort began in May 2014 and is ongoing. This interim report summarizes hydrogen sulfide (H_2S), sulfur dioxide (SO_2), and carbon monoxide (CO) measurements taken from June 1, 2014, to January 31, 2015, via RAE Systems, Inc., AreaRAE instruments.

START's tasks have included: (1) assembling and maintaining a network of off-site air monitoring stations with instrumentation and sampling devices to measure parameters of concern, (2) assisting EPA with data acquisition and management, (3) documenting the off-site air monitoring efforts, and (4) validating/verifying initial screening of the data. The objectives of this report are to present an interim summary of the AreaRAE CO, SO_2, and H_2S data acquired, including findings related to data validation, verification, and usability.

2.0 PROBLEM DEFINITION, BACKGROUND, AND SITE DESCRIPTION

EPA is conducting ongoing air monitoring and sampling at locations off site of WLLS during a pre-construction, baseline period prior to initiation of construction of a planned isolation barrier at WLLS. Air monitoring during the baseline period will provide data for use to (1) evaluate pre-construction concentrations of chemical and radiological parameters of potential concern in outdoor air, and (2) optimize the sampling and monitoring plan for the off-site air monitoring to occur during construction of the isolation barrier. During barrier construction, air monitoring will occur to address concerns that construction operations at WLLS could impact human health and the environment via release to ambient air of solid waste landfill gases of concern or of particulates with radiologically-impacted materials (RIM).

West Lake Landfill is an approximately 200-acre property including several closed solid waste landfill units that accepted wastes for landfilling from the 1940s or 1950s through 2004, plus a solid waste transfer station, a concrete plant, and an asphalt batch plant. WLLS is at 13570 St. Charles Rock Road in Bridgeton, St. Louis County, Missouri, approximately 1 mile north of the intersection of Interstate 70 and Interstate 270 (see Appendix A, Figure 1). WLLS was used for limestone quarrying and crushing operations from 1939 through 1988. Beginning in the late 1940s or early 1950s, portions of the quarried areas and adjacent areas were used for landfilling municipal refuse, industrial solid wastes, and construction/demolition debris. In 1973, approximately 8,700 tons of leached barium sulfate residues (a remnant from the Manhattan Engineer District/Atomic Energy Commission project) was reportedly mixed with approximately 39,000 tons of soil from the 9200 Latty Avenue site in Hazelwood, Missouri, transported to the WLLS, and used as daily or intermediate cover material.

In December 2004, the Bridgeton Sanitary Landfill—the last landfill unit to receive solid waste—stopped receiving waste pursuant to an agreement with the City of St. Louis to reduce potential for birds to interfere with Lambert Field International Airport operations. In December 2010, Bridgeton Landfill detected changes—elevated temperatures and elevated carbon monoxide levels—in its landfill gas extraction system operating at the South Quarry of the Bridgeton Sanitary Landfill portion of the Site (a landfill portion not associated with known RIM). Further investigation indicated that the South Quarry Pit landfill was undergoing an exothermic subsurface smoldering event (SSE). In 2013, potentially responsible parties committed to constructing an isolation barrier that would separate the Bridgeton Landfill undergoing the SSE from the RIM-containing portions of WLLS (EPA 2014).

3.0 SAMPLING STRATEGY AND METHODOLOGY

EPA and START began setup of the five off-site monitoring stations in April 2014; these activities included installations of electrical service, instrument weather housings, monitoring and sampling devices, and a wireless remote monitoring network. On June 1, 2014, setup of the AreaRAE detectors had been completed and acquisition of data for the pre-construction baseline period started at the following monitoring stations according the approved quality assurance project plan (QAPP) (Tetra Tech 2014) (see Appendix A, Figure 1):

Station 1 – Robertson Fire Protection District Station 2, 3820 Taussig Rd., Bridgeton, Missouri

Station 2 – Pattonville Fire Department District, 13900 St Charles Rock Rd., Bridgeton, Missouri

Station 3 – Pattonville Fire Department District Station 2, 3365 McKelvey Rd., Bridgeton, Missouri

Station 4 – Spanish Village Park, 12827 Spanish Village Dr., Bridgeton, Missouri

Station 5 – St. Charles Fire Department Station #2, 1550 S. Main St., St. Charles, Missouri.

The Station 1 through 4 locations were selected primarily for their positions proximate to and around WLLS (these stations are approximately 0.3 to 1 mile from WLLS, in various directions from WLLS). Station 5 was designated as a reference (or background) station, and its location was selected according to the criterion that it be frequently upwind of WLLS and farther away from WLLS than the other stations, but still within the general vicinity so as to be representative of the North St. Louis County and eastern St. Charles County area (see wind rose in Appendix A, Figure 1).

The parameters of potential concern identified in the QAPP (Tetra Tech 2014) included various radiological parameters related to the West Lake RIM, volatile organic compounds (VOC), CO, SO_2, and H_2S (interim radiological and VOC results have been summarized in Tetra Tech 2015a, b). The CO, SO_2, and H_2S measurements summarized herein were obtained by use of RAE Systems, Inc., AreaRAE detectors. The AreaRAE is a portable multi-gas monitor generally used by workers in potentially hazardous environments to provide real-time measurements from various internal sensors that monitor for toxic gasses (such as CO, SO_2, and H_2S), combustible gases, oxygen levels, and gamma radiation.

At each of the five monitoring stations, EPA has installed AreaRAE detectors equipped with CO, SO_2, and H_2S electrochemical sensors. Measurements from these sensors are transmitted wirelessly to a field command post computer and then logged by EPA Environmental Response Team's Viper data management software. At each of the five air monitoring stations, a measurement from each sensor is

recorded approximately every second following a non-zero measurement by the sensor (when a sensor reports a 0 parts per million [ppm] measurement, the following reading is recorded 3 minutes later).

4.0 INTERIM SUMMARY OF AREARAE DATA

The following sections present interim data summaries of the CO, SO_2, and H_2S AreaRAE data acquired during the ongoing baseline monitoring period. A manufacture's datasheet for the AreaRAE is in Appendix B.

4.1 DATA VALIDATION, VERIFICATION, AND USABILITY

The following sections discuss limitations on data usability with respect to the detection capability of the AreaRAE detectors and field-documented loss of calibration occurrences and other equipment issues.

4.1.1 Limitations Related to Minimum Increments of Measurement

The minimum increment of measurement for the AreaRAE CO, H_2S, and SO_2 sensors is 0.1 ppm (or 100 parts per billion). That is, the lowest non-zero reading provided by these sensors is 0.1 ppm, with the next lowest non-zero reading being 0.2 ppm, and so forth. This minimum increment of measurement is generally adequate for detecting releases that could cause acute exposures of concern; however, this minimum increment of measurement may render the data unusable for comparison to chronic health-based standards that are close to or less than 0.1 ppm.

4.1.2 Limitations Related to Two-Point Calibration Process

The AreaRAE detectors used at the five air monitoring stations are calibrated weekly in the field via a two-point calibration process using ambient air and standard reference gases. A "fresh air" calibration is used to set the zero points for the sensors and is conducted using outdoor ambient air. Following the fresh air calibration, a standard reference gas (or span gas) of a known concentration is sampled by the AreaRAE detector and used to set the second point of reference. Table 1 lists the reference gas concentrations used to set the second (or span) reference point.

TABLE 1

CALIBRATION REFERENCE GAS CONCENTRATIONS

AreaRAE Sensor	Calibration reference gas concentration (parts per million)
Carbon monoxide (CO)	50
Hydrogen sulfide (H_2S)	10
Sulfur dioxide (SO_2)	10

Measurements significantly larger or smaller than the calibration reference gas concentration are expected to be less accurate than measurements near the calibration reference gas concentration. Measurements near the minimum increment of measurement (0.1 ppm), including "0 ppm" readings, likely indicate concentrations similar to ambient air sampled during the fresh air calibration.

4.1.3 Limitation Related to Sensor Cross-Sensitivities

RAE Systems, Inc. reports that every AreaRAE electrochemical sensor has cross-sensitivity to other compounds (RAE Systems 2014). This cross-sensitivity, inherent to electrochemical sensors, results when gases other than the target gas chemically react with the sensor electrode. Table 2 lists some of the cross-sensitivities reported by RAE Systems, Inc. (see RAE Systems 2014).

TABLE 2

KNOWN CROSS-SENSITIVITIES FOR CO, H_2S, AND SO_2 AREARAE SENSORS

AreaRAE Sensor	Known Cross-Sensitive Chemicals
Carbon monoxide (CO)	acetylene, butane, chlorine, ethylene, ethylene oxide, hydrogen, isobutylene, pure nitrogen, and trichloroethylene
Hydrogen sulfide (H_2S)	carbon monoxide (CO), ethyl sulfide, ethylene, methyl mercaptan, methyl sulfide, nitric oxide, phosphine, sulfur dioxide (SO_2), turpentine
Sulfur dioxide (SO_2)	carbon monoxide (CO), nitric oxide, hydrogen sulfide (H_2S), hydrogen, hydrogen cyanide, acetylene, and ethylene

Notably, the H_2S and SO_2 sensors are reportedly cross-sensitive to CO.

4.1.4 Threshold Concentrations for Identifying Measurements of Interest

To address data usability issues regarding the aforementioned limitations of the AreaRAE detectors, threshold concentrations were established for identifying AreaRAE measurements of interest. A threshold for each of the sensors was established at 20 percent of the respective reference gas concentrations. These thresholds are listed in Table 3.

TABLE 3

THRESHOLD CONCENTRATIONS FOR BASELINE PERIOD EVALUATION

AreaRAE Sensor	Calibration reference gas concentration (parts per million)	Threshold concentration for identifying AreaRAE measurements of interest (parts per million)
Carbon monoxide (CO)	50	10
Hydrogen sulfide (H_2S)	10	2
Sulfur dioxide (SO_2)	10	2

4.1.5 Field Verification of Measurements

AreaRAE measurements equal to or exceeding threshold concentrations listed in Table 3 were evaluated by the START field team to assess for measurements potentially related to calibration or instrument issues. The review was conducted by cross-referencing dates and times of measurements of interest with any field documentation of calibration, maintenance, or other activities occurring near the stations during those times. This review identified several occurrences of measurements related (1) an AreaRAE detector affected by sensor drift[1] following calibration, (2) AreaRAE detectors mistakenly recorded by the Viper system during calibrations (resulting in recordings of readings of calibration reference gas), or (3) malfunctioning detectors. These measurements were flagged as invalid measurements in the database storing the AreaRAE measurements. These measurements are not evaluated in Section 5; however, they are shown on a plot in Appendix E along with annotations describing the circumstances affecting the measurements.

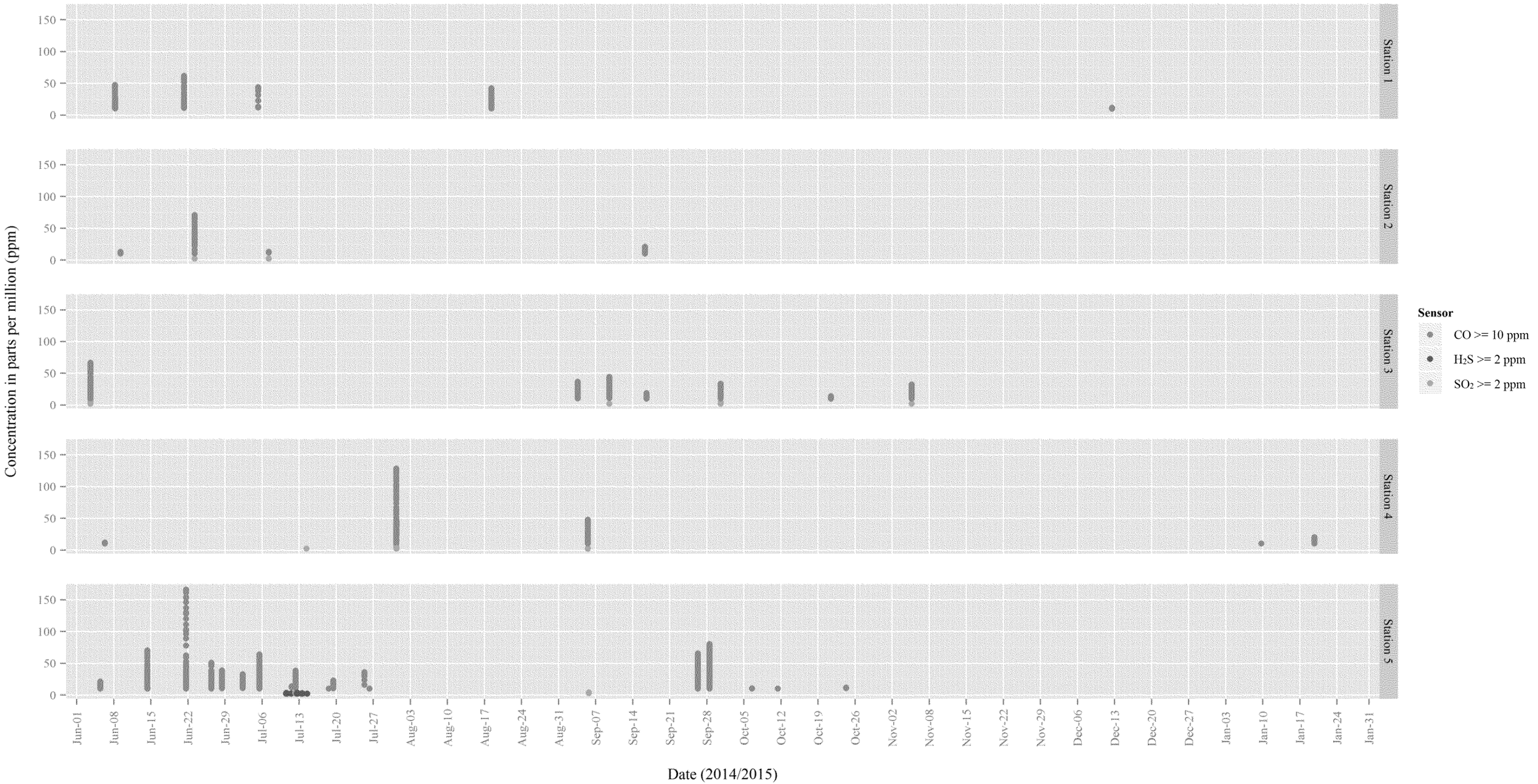
4.2 AREARAE RESULTS

Exhibit 1 shows a time series plot of AreaRAE CO, H_2S, and SO_2 data acquired at the five stations from June 1, 2014, to January 31, 2015. Weekly plots, allowing expanded scales for closer examination of the measurements, are in Appendices C and D.

[1] Sensor drift is a condition where variations of sensor response is experienced with time and can be caused for various reasons including fouling or aging of the sensor.

EXHIBIT 1

TIME SERIES PLOT OF CARBON MONOXIDE, HYDROGEN SULFIDE, AND SULFUR DIOXIDE MEASUREMENTS BY AREARAE DETECTORS



5.0 ANALYSIS OF RESULTS

The plots of the AreaRAE CO, H_2S, and SO_2 measurements in Exhibit 1 and Appendices C and D illustrate the following characteristics of the data:

- Most measurements exceeding threshold values listed in Table 3 were CO sensor readings (10 ppm is the threshold value for CO). The CO sensor readings appeared in discrete events lasting only several minutes (this can be observed in the weekly plots in Appendix C). These events appeared to occur somewhat regularly at each of the air monitoring stations (including the reference station—Station 5) during the summer and fall months. The short durations of these events suggest presence of one or more CO sources near the detectors, possibly engine exhaust from nearby vehicles, emergency generators (Stations 2 and 5 are located near fire station emergency backup generators that are tested weekly), or lawn maintenance equipment.

- SO_2 sensor readings above the threshold value of 2 ppm occurred less frequently than CO sensor readings above 10 ppm, but often coincided with CO events and also occurred over short durations lasting minutes or less. As noted previously, the AreaRAE SO_2 sensor is reported to be cross-sensitive to CO.

- H_2S sensor readings above the threshold value of 2 ppm occurred only at Station 5—the reference station; the readings occurred mid-day over 5 consecutive days between July 10 and 14, 2014. Station 5 H_2S readings from these days were further examined by plotting them with hourly temperature and wind direction measurements from the Lambert-St. Louis International Airport meteorological station which is approximately 2 miles east of WLLS (NOAA 2015). This plot, presented in Appendix D, shows the Station 5 H_2S measurements responding to changes in temperature (H_2S measurements generally increased with increasing temperature and decreased with decreasing temperature), but not to changes in wind direction.

- The H_2S measurements maintained a pattern of increasing mid-day with temperature even though wind direction changed over the 5 consecutive days (on July 10, winds were out of the east, changing to southerly winds on July 11, then varying from the southwest to northwest on July 13 and 14). Because emissions from a stationary source would have been carried in the direction of the wind reaching Station 5 when the source was upwind, the Station 5 H_2S readings, which did not vary with wind direction, do not appear attributable to a stationary source. Overall, the Station 5 July 10 – 14, 2014 H_2S measurements do not appear to be representative of actual ambient H_2S concentrations and are likely related to an unknown problem with the detector (such as a post-calibration sensor drift condition).

Overall, plots of the AreaRAE data illustrate CO sensor readings equal to or above 10 ppm occurred during several short-term events at each of the five air monitoring stations; again, these exceedances lasted only several minutes and are suspected to be attributable to engine exhaust emitted near the monitoring stations. SO_2 sensor readings equal to or above 2 ppm occurred at Stations 2, 3, 4, and 5, were short in duration (several minutes), and often coincided with elevated CO sensor readings. H_2S sensor readings above 2 ppm occurred at Station 5 only, but because these readings do not appear characteristic of an actual source, the measurements and are likely related to an unknown problem with the detector. Other than the aforementioned Station 5 July 10-14, 2014 H_2S measurements and those

measurements qualified as not usable due to equipment issues (those measurements appearing in Appendix E, Exhibit E-1), the AreaRAE CO, H_2S, and SO_2 sensor readings collected during the baseline monitoring period appear to be typical for a multi-month, continuous monitoring campaign of an outdoor urban environment and would be useful for comparison to future AreaRAE monitoring during construction of the planned isolation barrier at WLLS.

6.0 SUMMARY OF OBSERVATIONS

Since June 1, 2014, ongoing baseline off-site air monitoring for CO, H_2S, and SO_2 has been occurring according to the approved QAPP (Tetra Tech 2014) at five air monitoring stations off of the WLLS. Tetra Tech has summarized, assessed for usability, and evaluated the CO, H_2S, and SO_2 data acquired between June 1, 2014, and January 31, 2015. In examining inherent limitations of the AreaRAE detectors—a portable multi-gas monitor designed for use by workers in unknown, potentially hazardous emergency environments—Tetra Tech noted that the data are likely usable for detection of releases that could cause acute exposures of concern, but likely unusable for comparison to chronic health-based standards close to or less than the instrument's minimum increment of detection of 0.1 ppm (monitoring equipment with lower limits of detection could be employed if such a comparison is desired). The acquired pre-construction, baseline CO, H_2S, and SO_2 data were plotted to present a summary of the measurements. Overall, the CO, H_2S, and SO_2 sensor readings generally appeared to be typical for a multi-month, continuous monitoring campaign of an outdoor urban environment and the measurements, as qualified, may be useful for comparison to future AreaRAE measurements collected during construction of the planned isolation barrier at WLLS.

7.0 REFERENCES

National Oceanic and Atmospheric Administration (NOAA). 2015. National Climatic Data Center Quality Controlled Local Climatological Data (QCLCD). Available online at: http://cdo.ncdc.noaa.gov/qclcd/QCLCD. Last accessed February 23.

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Tetra Tech, Inc. (Tetra Tech). 2014. Quality Assurance Project Plan for Baseline Off-Site Air Monitoring and Sampling, West Lake Landfill Site, Bridgeton, Missouri. May 27.

Tetra Tech. 2015a. Interim Data Summary of Radiological Parameters Analyzed During Ongoing Baseline Off-Site Air Monitoring, West Lake Landfill Site, Bridgeton, Missouri. January 19.

Tetra Tech. 2015b. Interim Data Summary of Volatile Organic Compounds Sampling Results During Ongoing Baseline Off-Site Air Monitoring, West Lake Landfill Site, Bridgeton, Missouri. January 19.

U.S. Environmental Protection Agency (EPA). 2014. Administrative Settlement Agreement and Order on A Consent for Removal Action – Preconstruction Work. EPA Docket No. CERCLA-07-2014-0002. April 20.

APPENDIX A

FIGURE

Station 1 - Robertson Fire Protection District Station 2
(0.27 miles from West Lake Landfill)

Station 2 - Pattonville Fire Protection District Headquarters
(0.60 miles from West Lake Landfill)

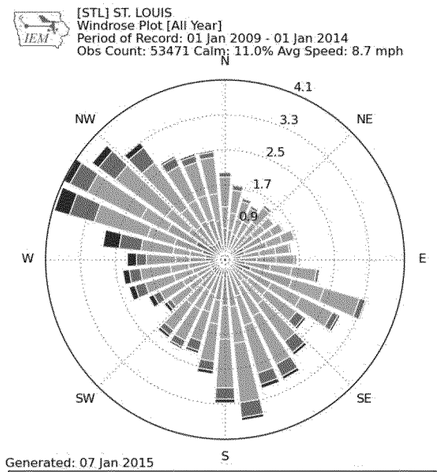
Station 5 - St. Charles Fire Department Station 2
(2.34 miles from West Lake Landfill)

Station 4 - Spanish Village Park
(0.42 miles from West Lake Landfill)

Station 3 - Pattonville Fire Department Station 2
(1.05 miles from West Lake Landfill)

Legend

- Off-site air monitoring station
- Bridgeton Landfill
- West Lake Landfill Site Operable Unit 1 (radiological area)



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0 1,000 2,000

Feet

Source: ArcGIS Online Aerial Imagery, 2013; Iowa State University of Science and Technology, 2015

West Lake Landfill
Bridgeton, Missouri

Figure 1

Off-Site Air Monitoring Stations

TETRA TECH

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APPENDIX B

RAE SYSTEMS AREARAE DATASHEET

AreaRAE

Rapidly Deployable, Wireless, Multi-channel, Compact Multi-gas Monitor

The **AreaRAE** is a one-to-five sensor gas detector equipped with a wireless RF (radio frequency) modem which allows the unit to communicate and transmit readings and other information on a real-time basis with a remotely located base controller.

In stand alone operation, the **AreaRAE** is a rugged, weather-resistant, portable monitor that can run over 24-hours on either rechargeable Lithium-ion or alkaline batteries. It is also the first "lunchbox" type multi-sensor instrument able to include a photoionization detector (PID) for parts-per-million measurement of volatile organic compounds (VOCs), as well as LEL, O_2 and up to two electrochemical toxic sensors for measurement of specific toxic substances such as CO and H_2S.

The RF modem allows real-time data transmissions with a base controller located up to two-miles away from the **AreaRAE** detector. A personal computer can be used as the base station for an **AreaRAE** system. The standard ProRAE Remote software used to control **AreaRAE** systems is capable of monitoring the input of up to 32 remotely-located monitors.

AreaRAE options include the ability to track and display readings from remotely located detectors on a GPS map.

The **AreaRAE** is ideal for HazMat and other emergency response monitoring programs. **AreaRAE** detectors can be used to quickly establish an emergency perimeter by setting out multiple monitors at strategic locations, then backing off to a position of safety to monitor readings over the wireless link.

The **AreaRAE** is available individually or as part of the Rapid Deployment Kit (RDK) system package.

Key Features

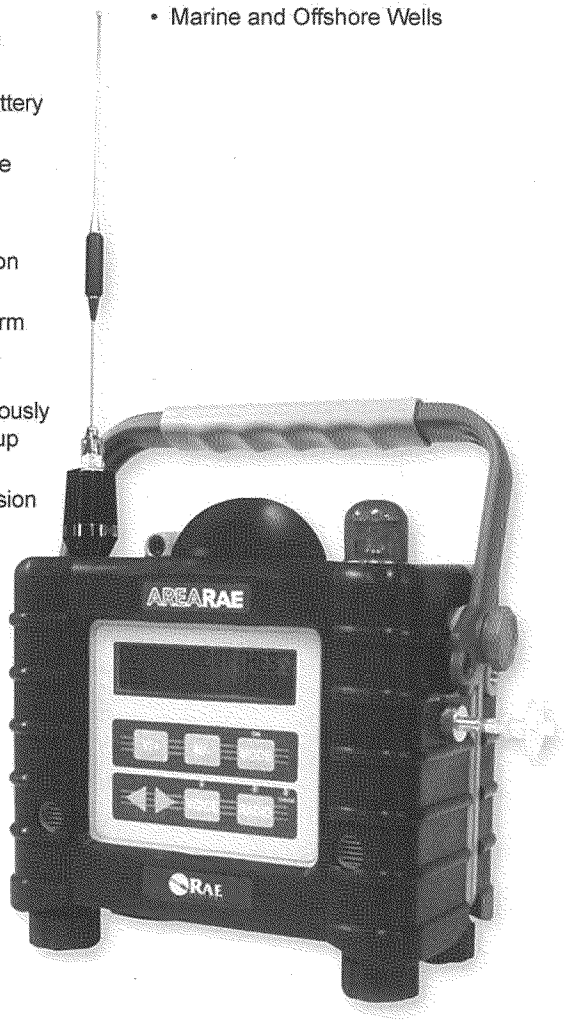
- Up to five sensors (PID, LEL, O_2 and two toxic)
- Loud buzzer and large, extra-bright warning light
- Large LCD display and keypad
- Rugged, weather-resistant housing
- Built-in pump
- Interchangeable Li-ion or alkaline battery pack
- Continuous operation via AC source

Additional Advantages

- Real-time wireless data transmission with built-in RF modem
- View real-time sensor data and alarm status at headquarters or command center
- ProRAE Remote software simultaneously controls and displays readings for up to 32 remote detectors
- License free, ISM band RF transmission with communication range up to 2 miles (extendable with RAELink Repeaters)
- Optional wall-mounting bracket or field mounting tripod adapter
- Optional GPS provides ability to track and display readings from remote detectors

Applications

- HazMat and Emergency Response
- Refineries and Petrochemical Plants
- Confined Space Entry
- Power Plants
- Pulp and Paper Industry
- Plant and Mill Turnarounds
- Marine and Offshore Wells



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RAE SYSTEMS

Specifications*

Sensor Specifications

Gas Monitor	Range	Resolution
Oxygen	0-30.0%	0.1%
Combustible	1-100% LEL	1% LEL
VOCs	0-200.0 ppm	0.1 ppm
	200-2,000 ppm	1 ppm
Carbon Monoxide	0-500 ppm	1 ppm
Hydrogen Sulfide	0-100 ppm	1 ppm
Sulfur Dioxide	0-20.0 ppm	0.1 ppm
Nitric Oxide	0-250 ppm	1 ppm
Nitrogen Dioxide	0-20.0 ppm	0.1 ppm
Chlorine	0-10.0 ppm	0.1 ppm
Hydrogen Cyanide	0-100 ppm	1 ppm
Ammonia	0-50 ppm	1 ppm
Phosphine	0-5.0 ppm	0.1 ppm

Detector Specifications

Size	9.25"L x 5.0"W x 9.25"H (w/o handle)
Weight	8.5 lbs. (3.9 kg) with battery pack
Detector	Up to five sensors (O_2, combustible, two toxic and VOC), electrochemical sensors for toxic gases and oxygen, photoionization sensor for VOC, catalytic combustion sensor for combustible gases
Battery	Rechargeable, 7.4V/4.5Ah, Lithium-ion battery pack with built in charger (less than 10 hours charge time) or a 6 C-size alkaline battery pack
Operating Hours	36 hrs continuous stand-alone operation, 24 hrs continuous wireless operation (Lithium-ion battery), 18 hrs continuous wireless operation (alkaline battery)
Display	2 line, 16 digit LCD with manually activated LED back light
Keypads	3 operation and 4 programming keys
Direct Readout	Instantaneous values, sensor name, high and low values for all detectors, TWA and STEL values for toxic gases and VOCs, battery voltage and elapsed time
Alarm	Flashing red LED cluster to indicate exceeded preset limits, low battery or sensor failure
Alarm Setting	Separate alarm limit settings for TWA, STEL, Low and High alarm
Audible Alarm	100dB buzzer at 10cm (typical)
Visual Alarm	Flashing red LED cluster
Alarm Mode	Latching/automatic reset
Datalogging	4000 points for each sensor with time stamp, serial number, user ID, site ID
Data Storage	20,000 readings (64 hours, 5 channels at 1 minute intervals) in non-volatile memory
Datalog Interval	Programmable 1-3600 sec
Communication	Upload data to PC and Download monitor setup from PC through RS-232 link to serial port on PC
EM Immunity	No effect when exposed to 0.43 mW/cm^2 RF interference (5 watt transmitter at 12 inch)
Intrinsic Safety	UL and CSA Classified for use in Class 1, Division II, Groups A,B, C, and D (w/ 900 MHz modem)
Frequency	902 to 928 MHz (License free) or 2.400 to 2.4835 GHz (License free, 3 user selectable channels)
RF Range	Up to 2 miles (900 MHz) - extendable with RAELink Repeaters
Error Detection	32 bit CRC, resend on error

Detector Specifications (continued)

Calibration	Two-point field calibration for fresh air and standard reference gas
Sampling pump	Internal integrated diaphragm pump with programmable High (400cc/min) and Low (300cc/min) flow rate settings
Low Flow Alarm	Auto shut off pump at low flow condition
Temperature	-4° to 113°F (-20° to 45°C)
Humidity	0% to 95% relative humidity (non-condensing)
Attachment	Shoulder strap, optional tripod/wall mounting bracket
Optional	Integrated GPS receiver

*Ongoing projects to enhance our products means that these specifications are subject to change

Monitor only includes:
- Monitor as specified
- Sensors as specified
- Carbon filters (for units with CO)
- Calibration adapter
- Quick reference guide
- Operation and maintenance manual
- Shoulder strap
- Rechargeable Lithium-ion battery pack
- 120/240 VAC AC/DC Adapter
- Spare alkaline battery pack
- 10 spare external filters
- Hard transport case with pre-cut foam
- 15' (5M) Teflon® tubing
- Tool kit

Instrument with calibration kit also includes:
- Calibration gas (kit may contain multiple cylinders depending on the sensors installed)
- Calibration regulator and tubing (kit may contain a second regulator depending on the types of calibration gases included)
- Hard transport case with pre-cut foam

Datalogging Monitors also include:
- Software, ProRAE Suite Package for Windows 98, NT, 2000 and XP
- Computer interface cable

ProRAE Remote Basic Host Software Package includes:
- ProRAE Remote Software for Windows 98, NT, 2000 and XP
- RAELink Modem

AreaRAE Model Numbers:
- AreaRAE with RF modem: PGM-5020
- AreaRAE with RF modem & GPS option: PGM-5020

AreaRAE

ISO 9001 CERTIFIED

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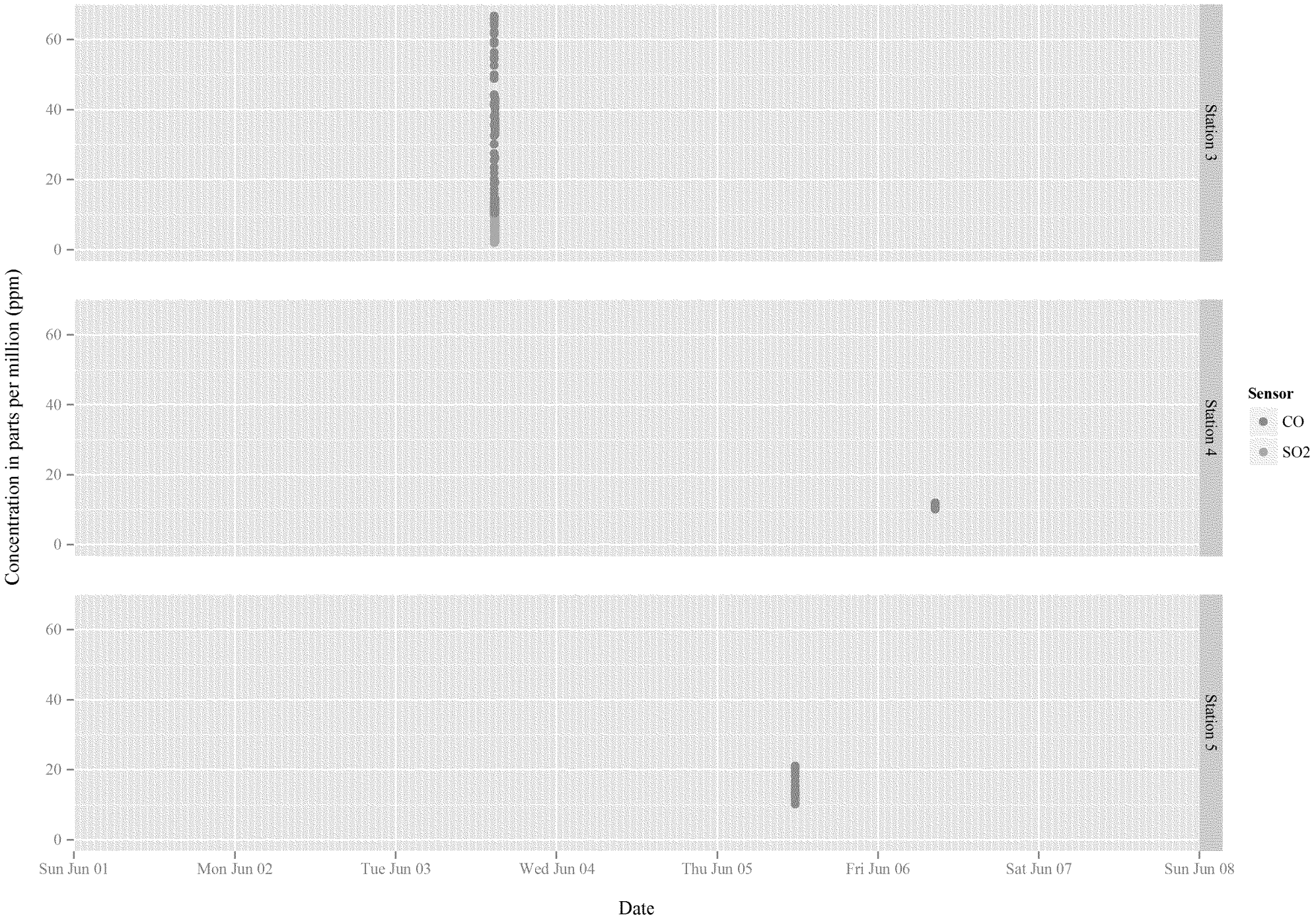
RAE SYSTEMS

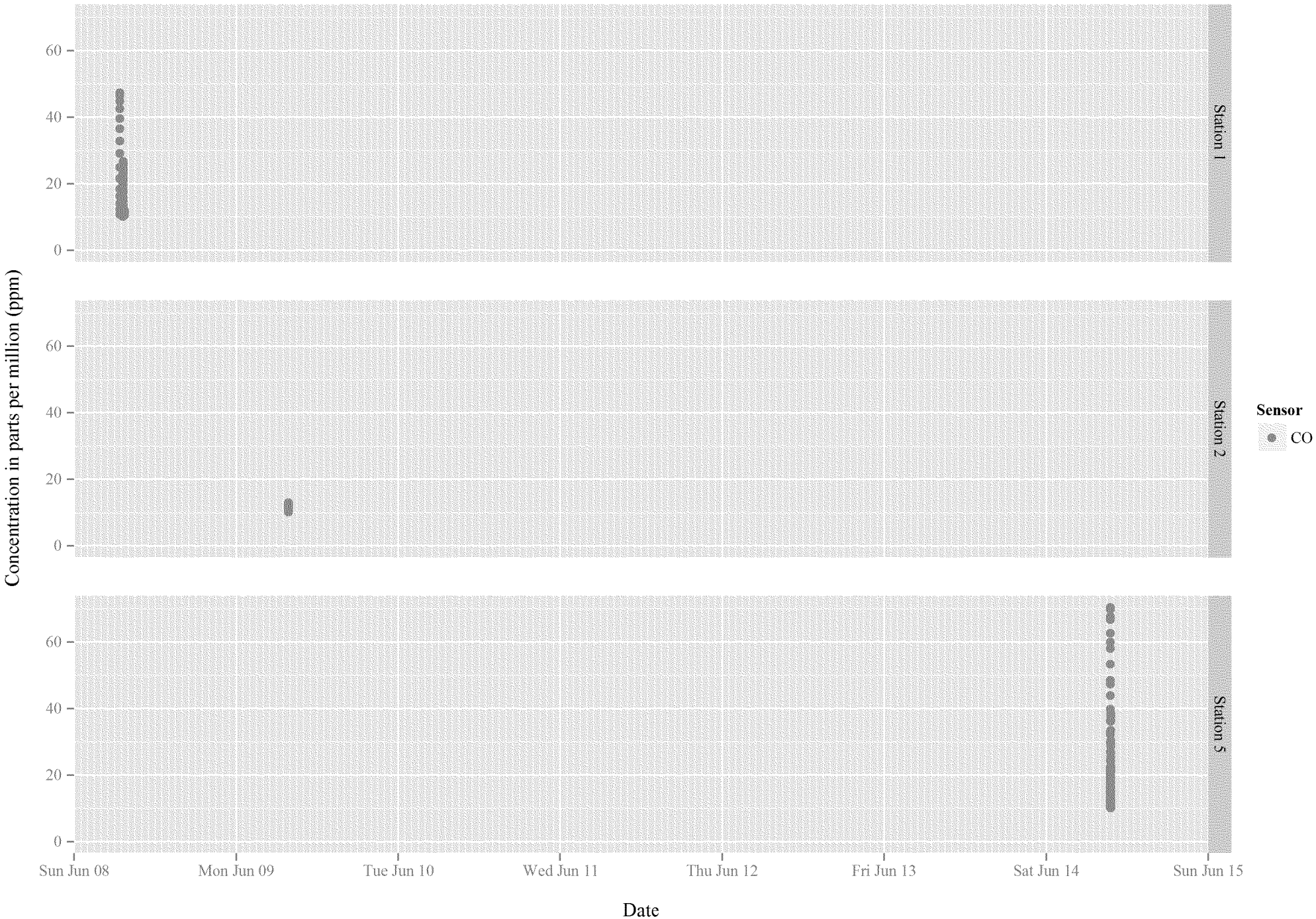
APPENDIX C

WEEKLY PLOTS OF AREARAE MEASUREMENTS

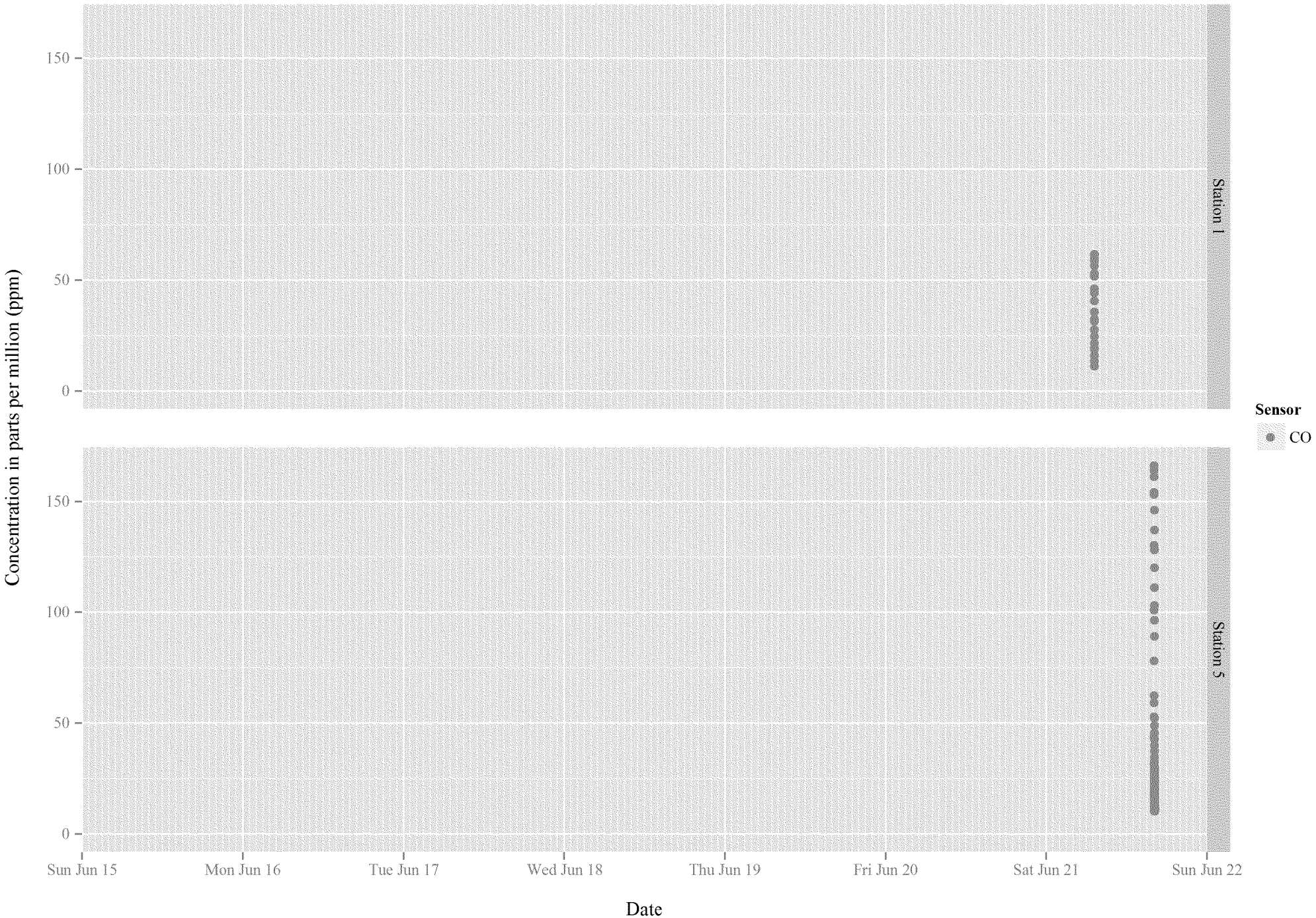
Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



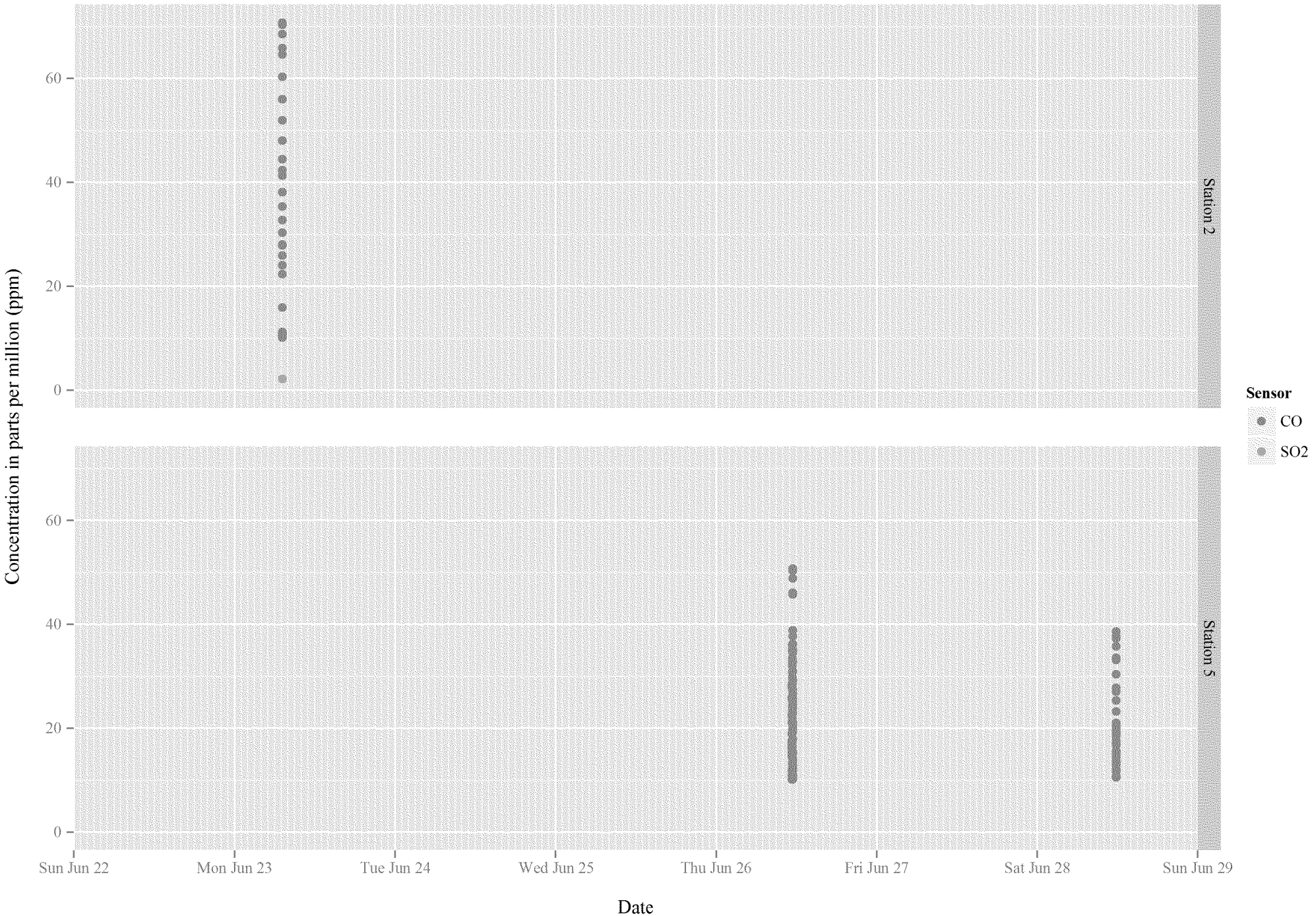
Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



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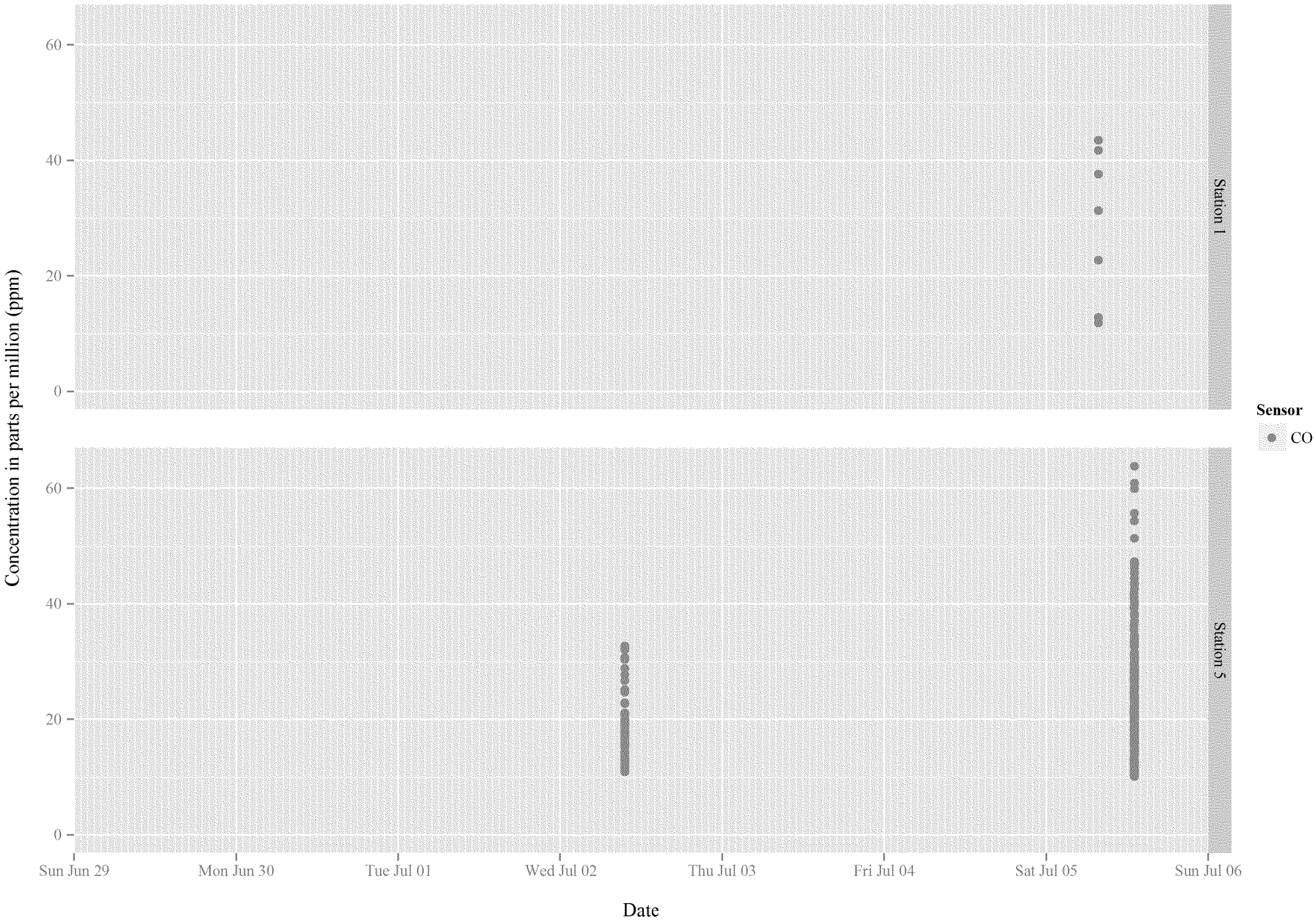

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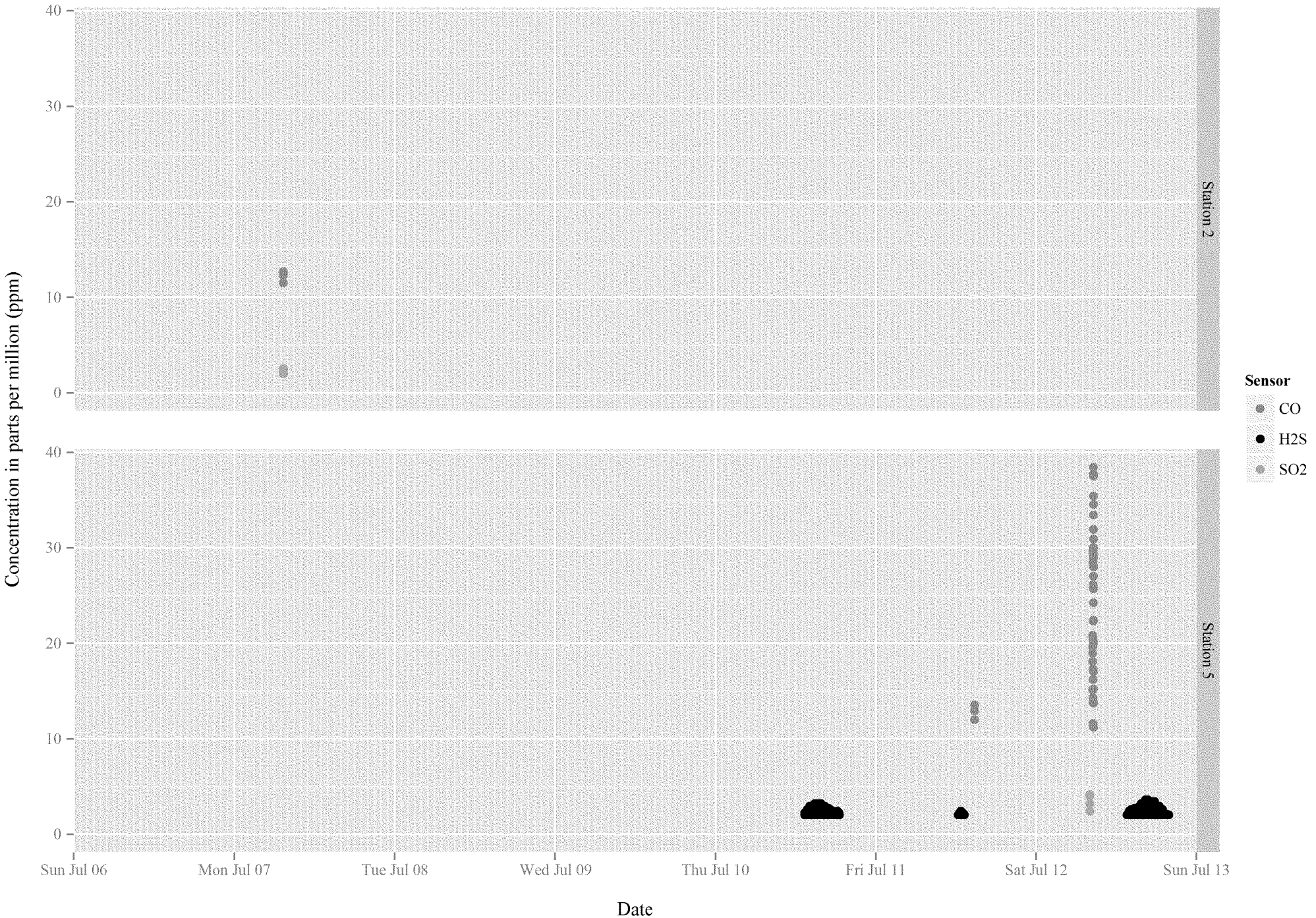
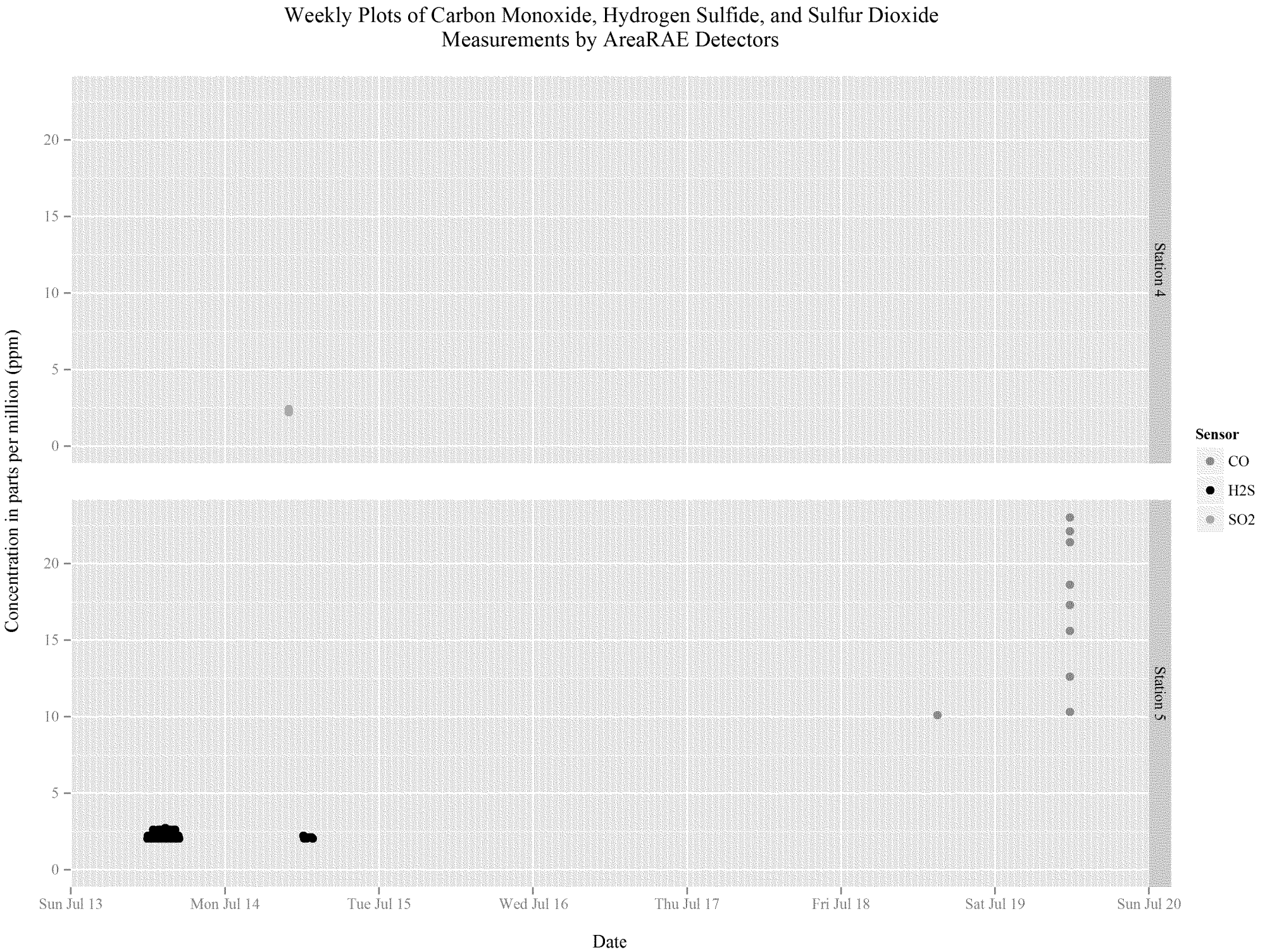
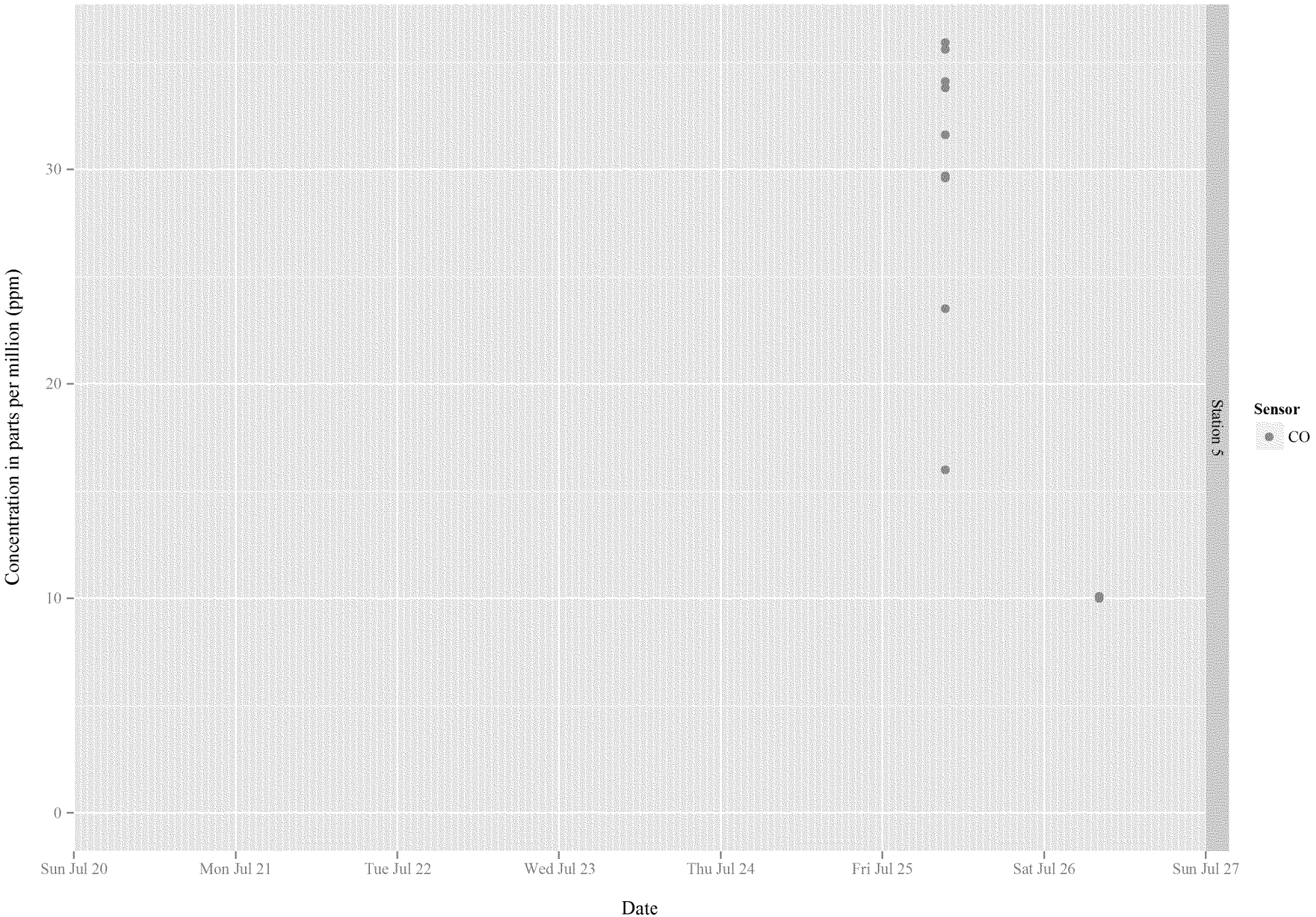
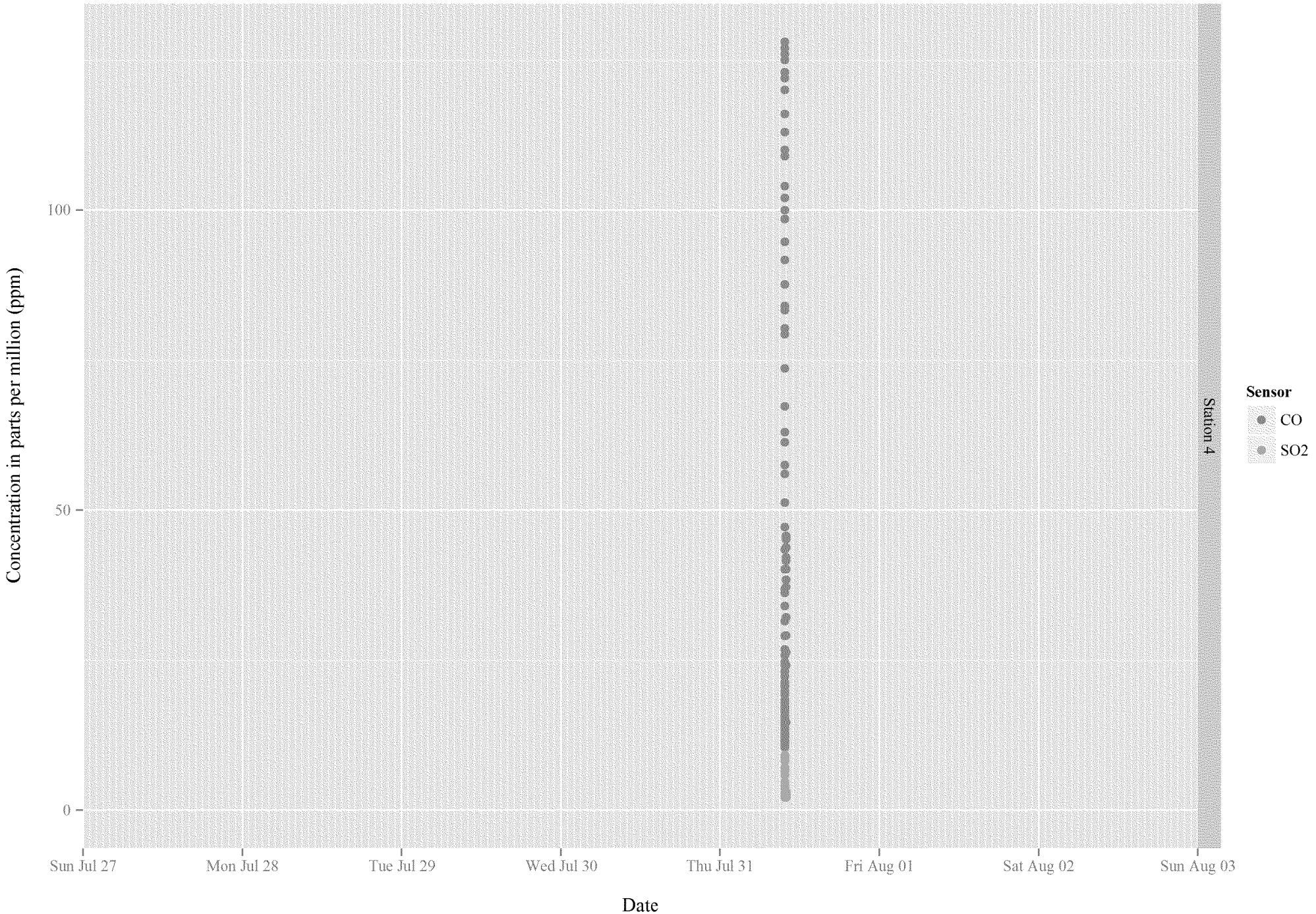



Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide
Measurements by AreaRAE Detectors
Concentration in parts per million (ppm)
0
5
10
15
20
Station 4
Station 5
Sun Jul 13
Mon Jul 14
Tue Jul 15
Wed Jul 16
Thu Jul 17
Fri Jul 18
Sat Jul 19
Sun Jul 20
Date
Sensor
CO
H2S
SO2

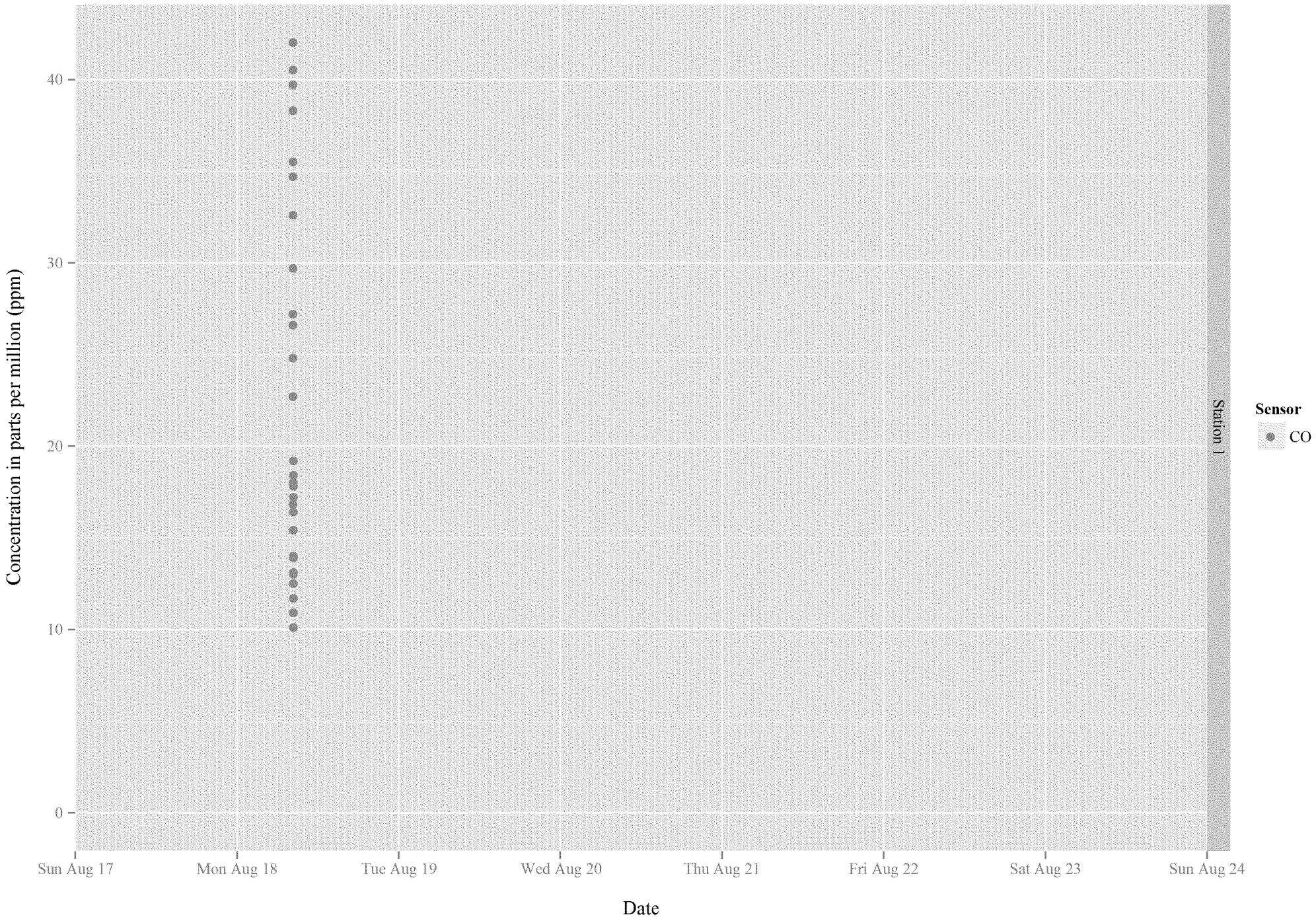
Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



Weekly Plots of Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements by AreaRAE Detectors



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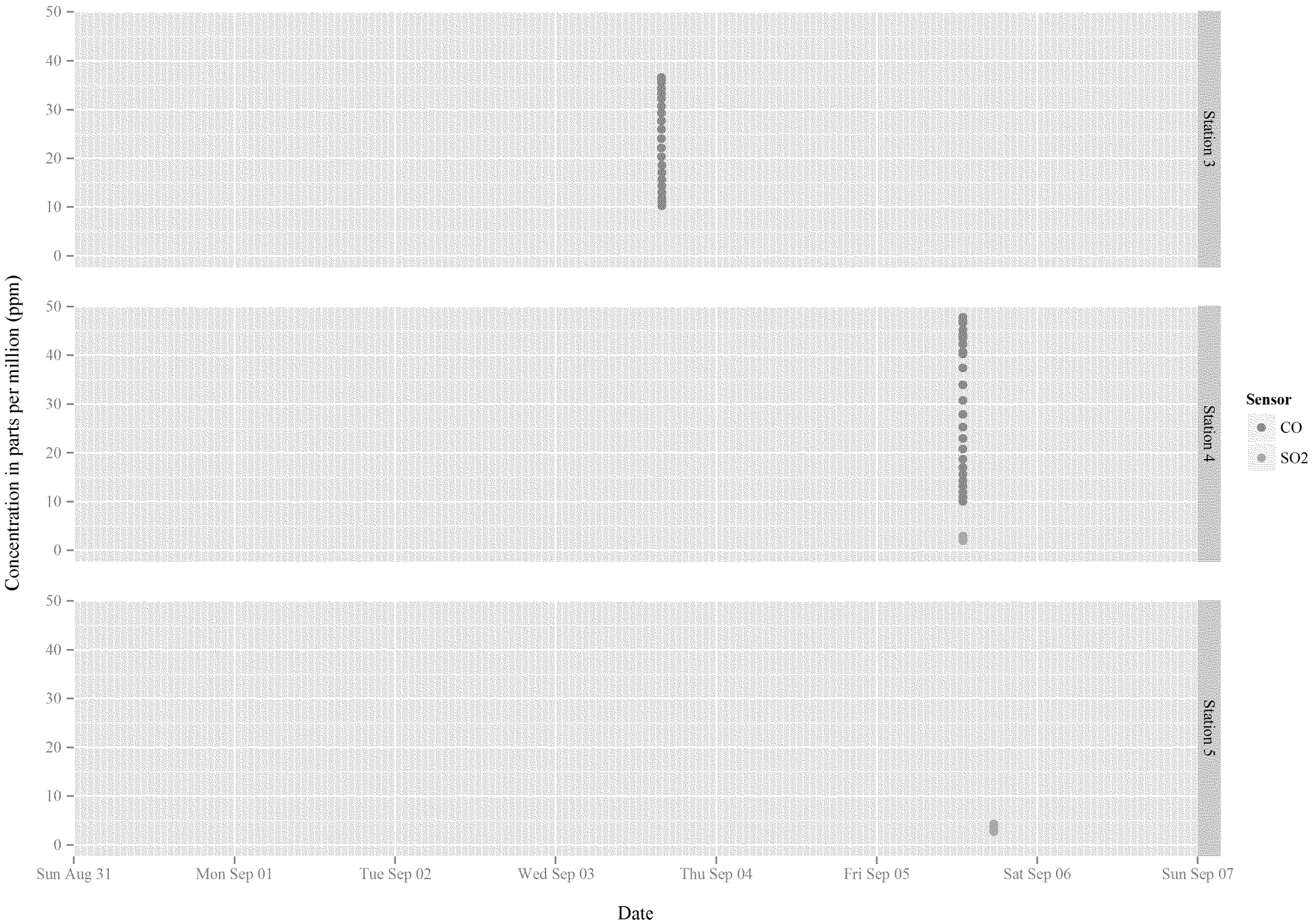

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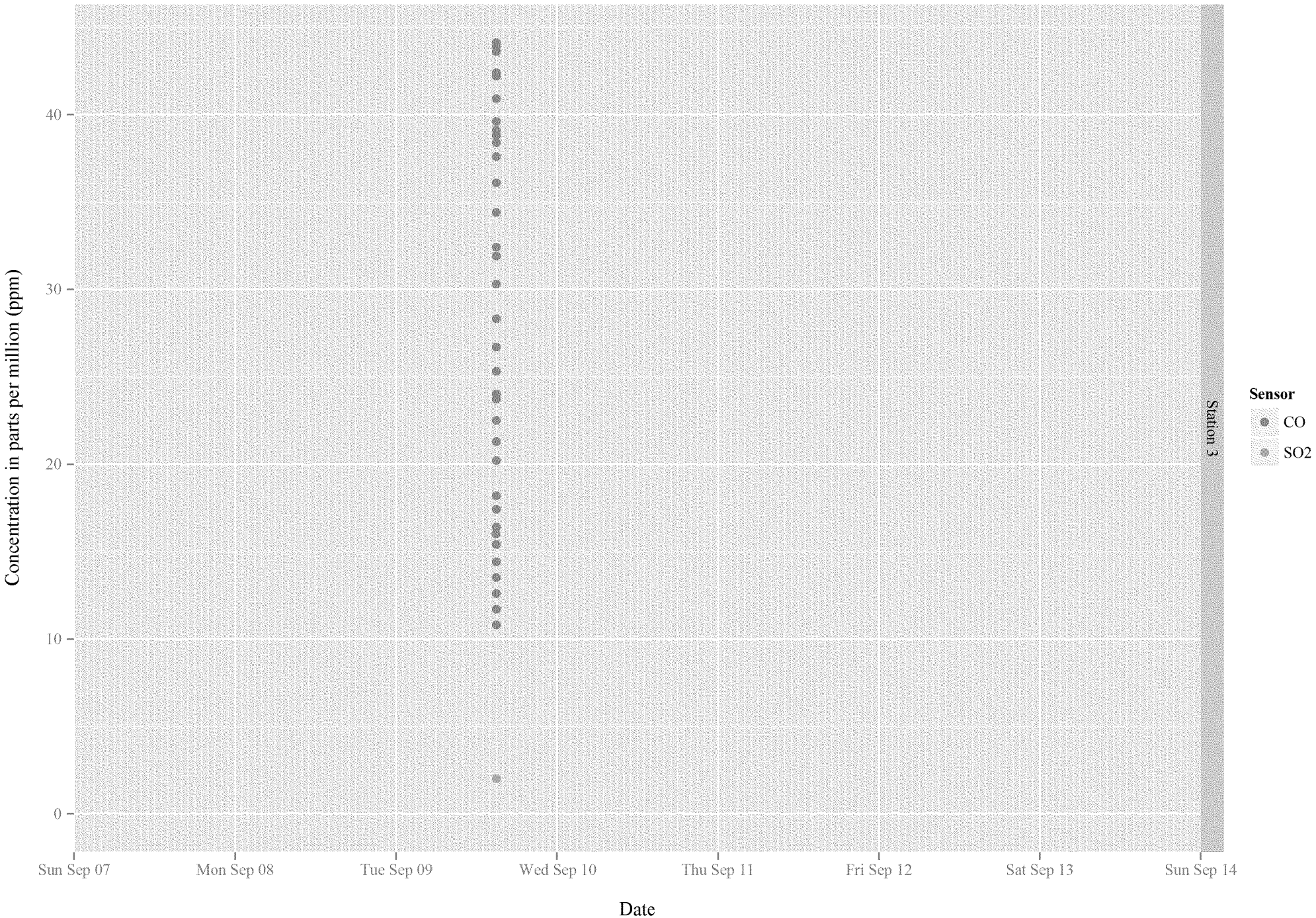

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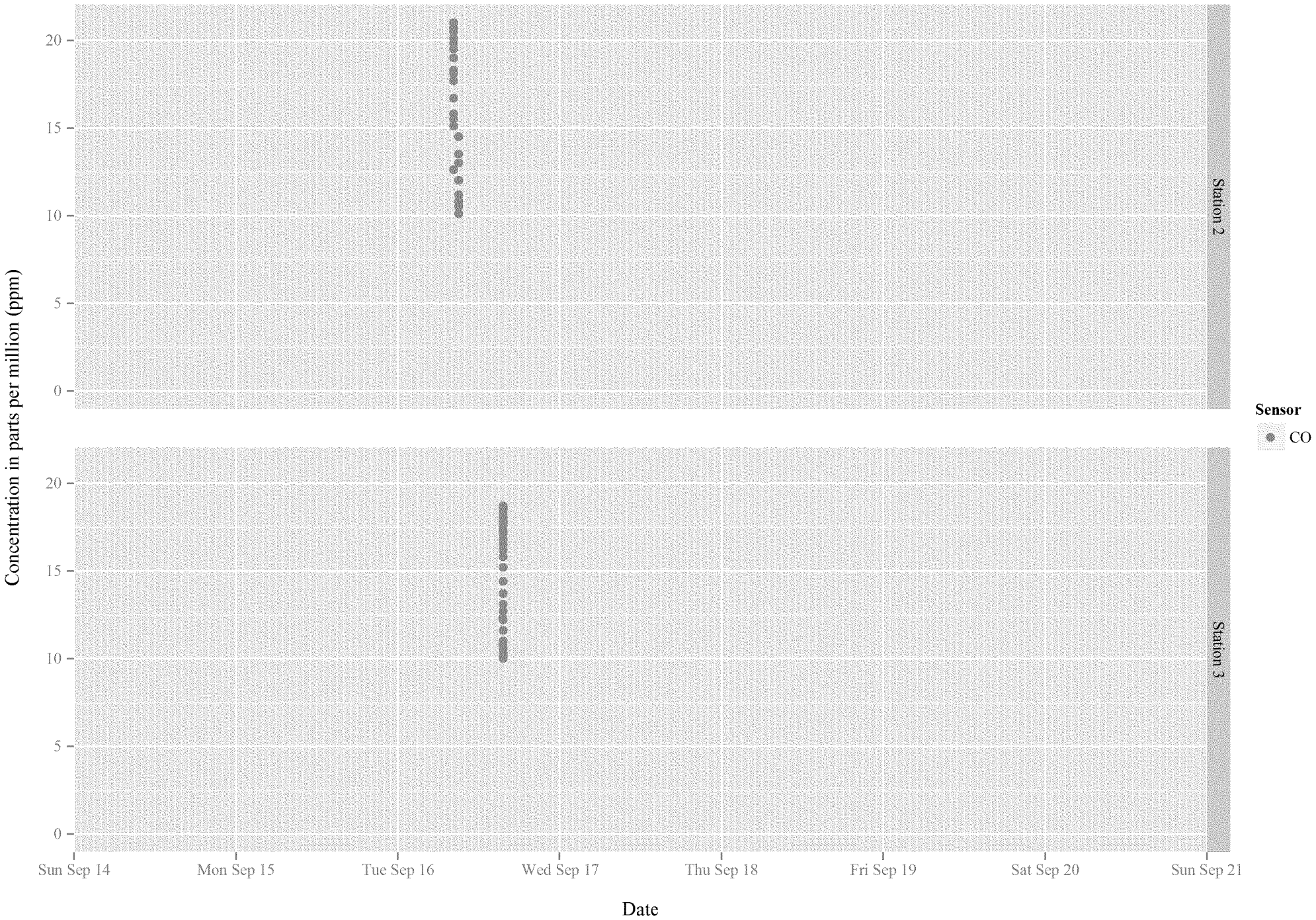

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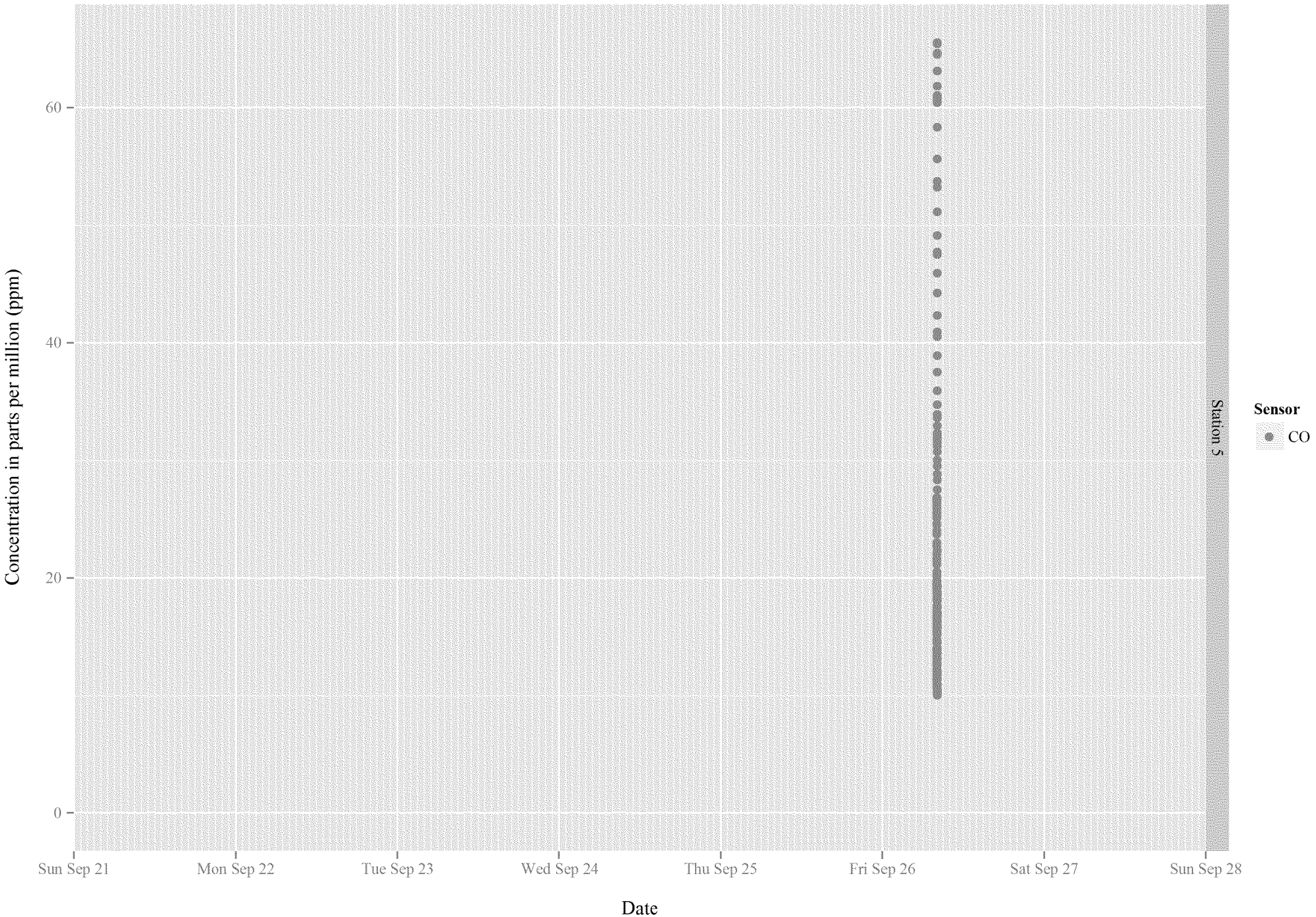

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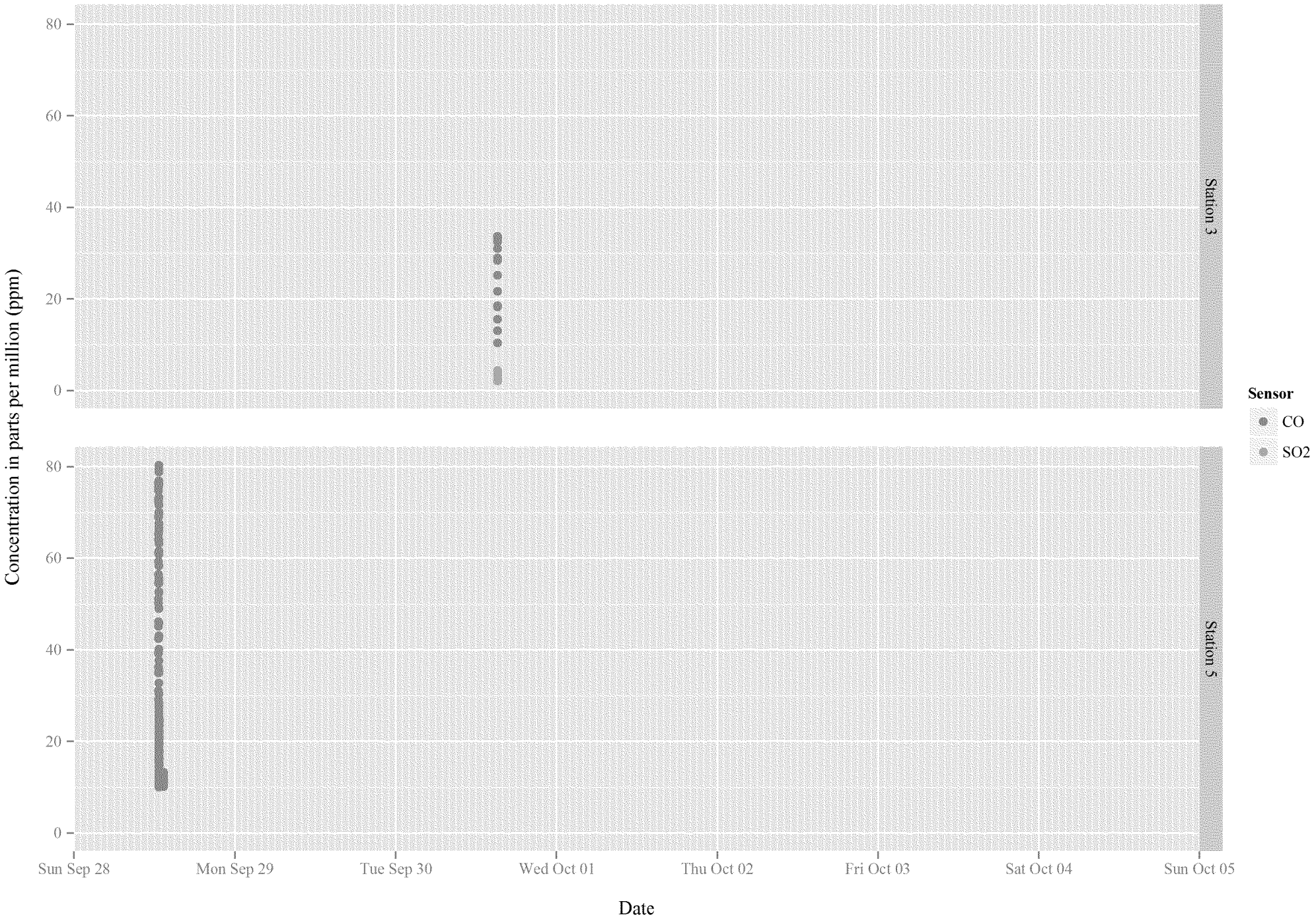

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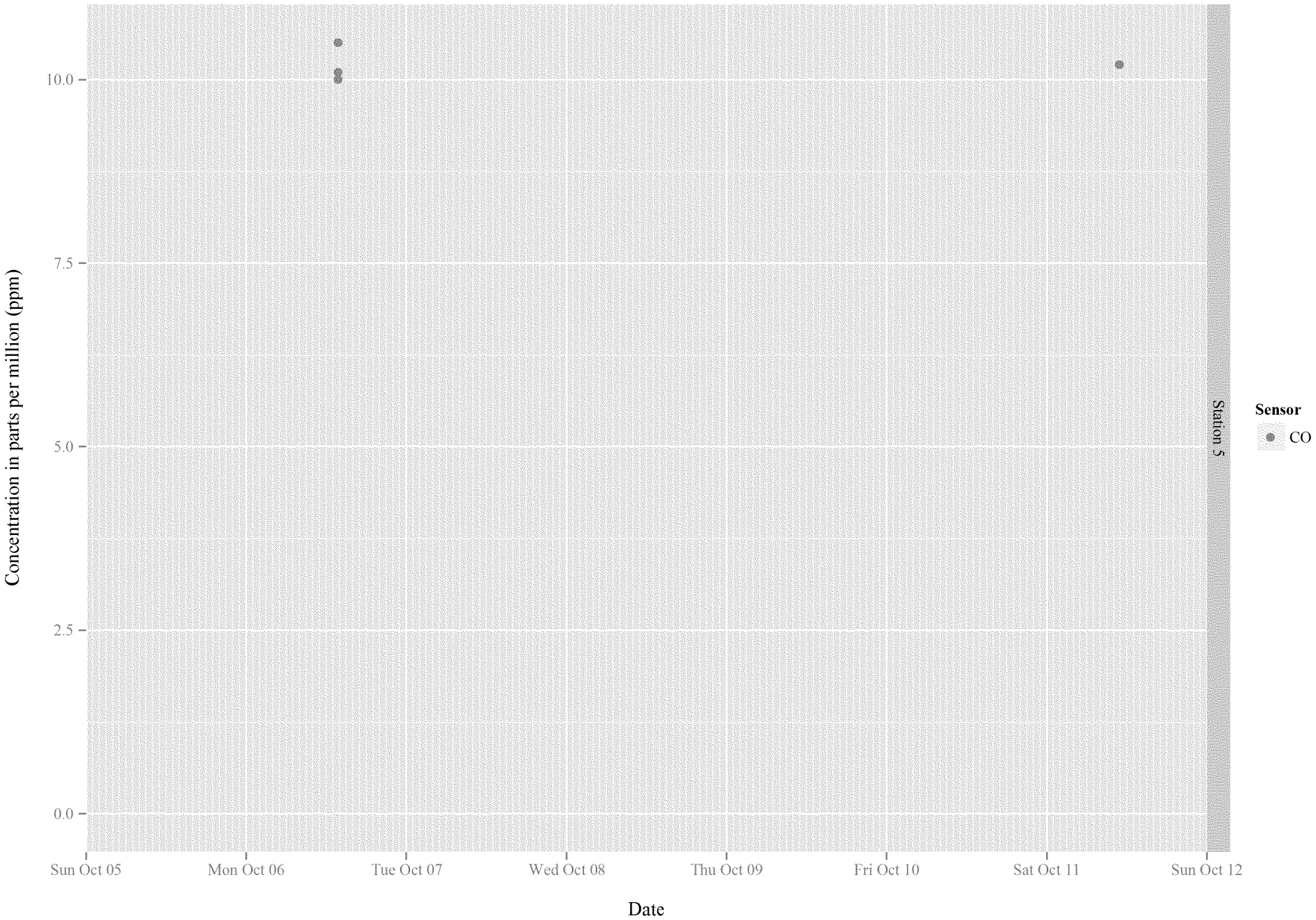

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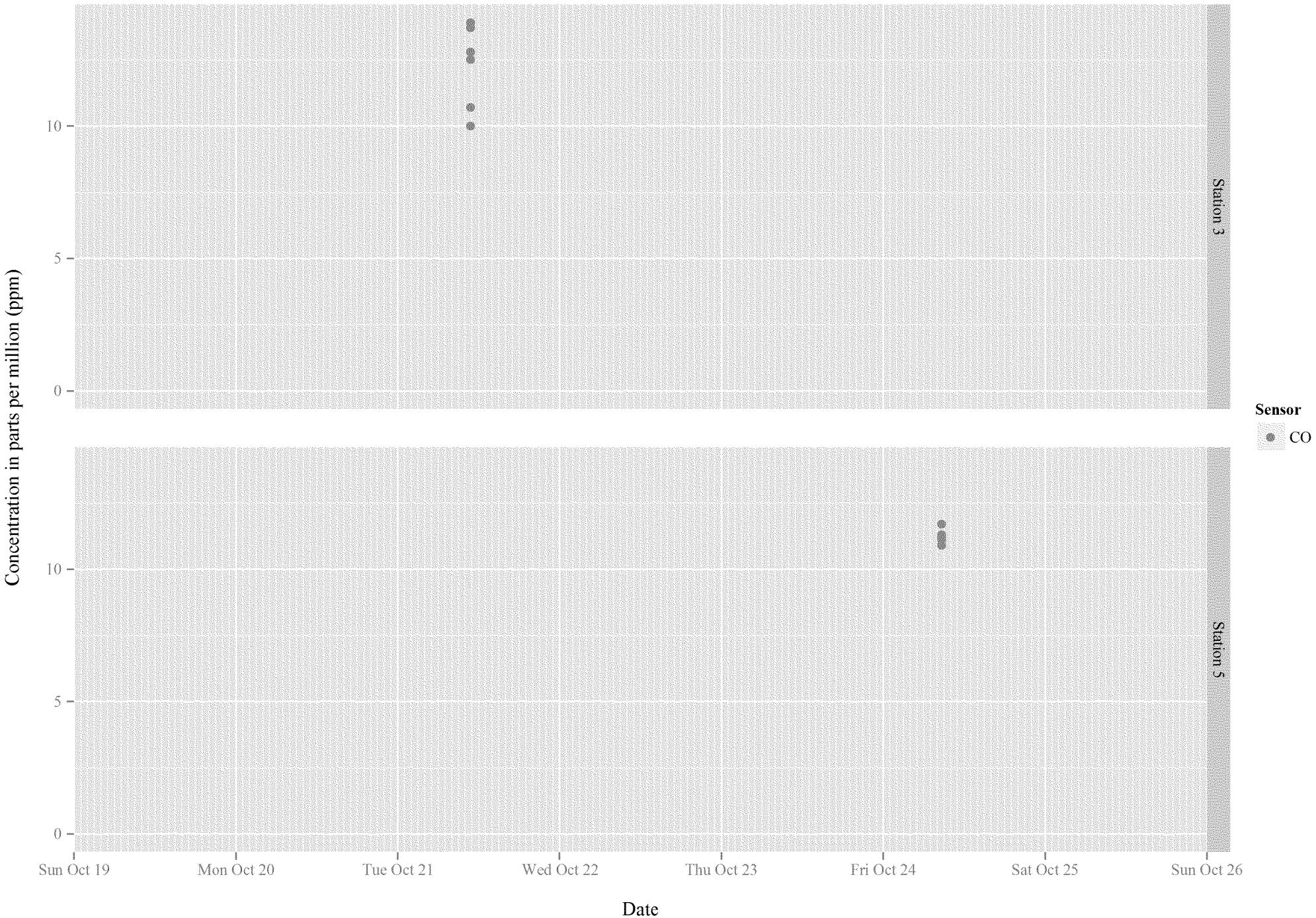

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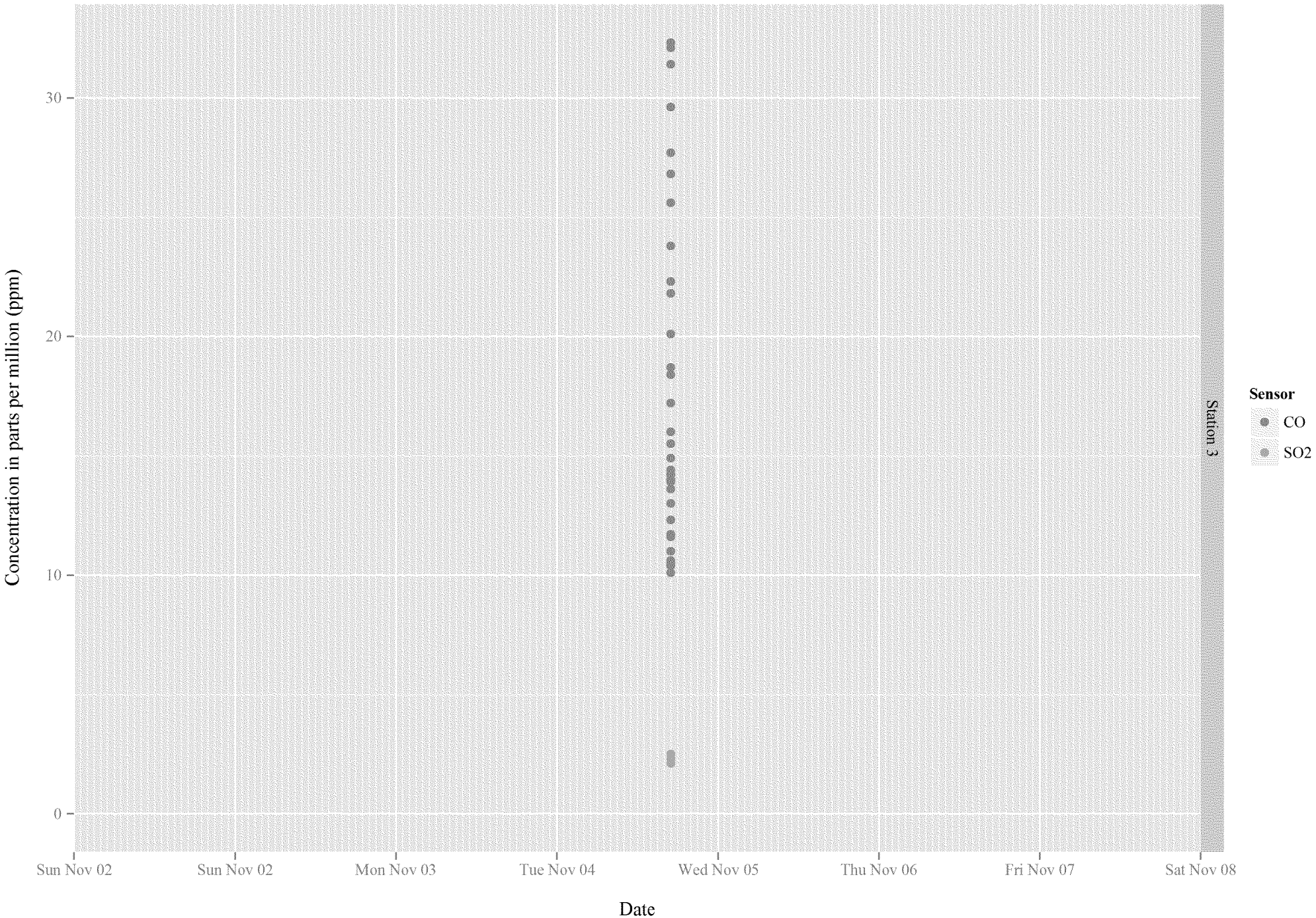

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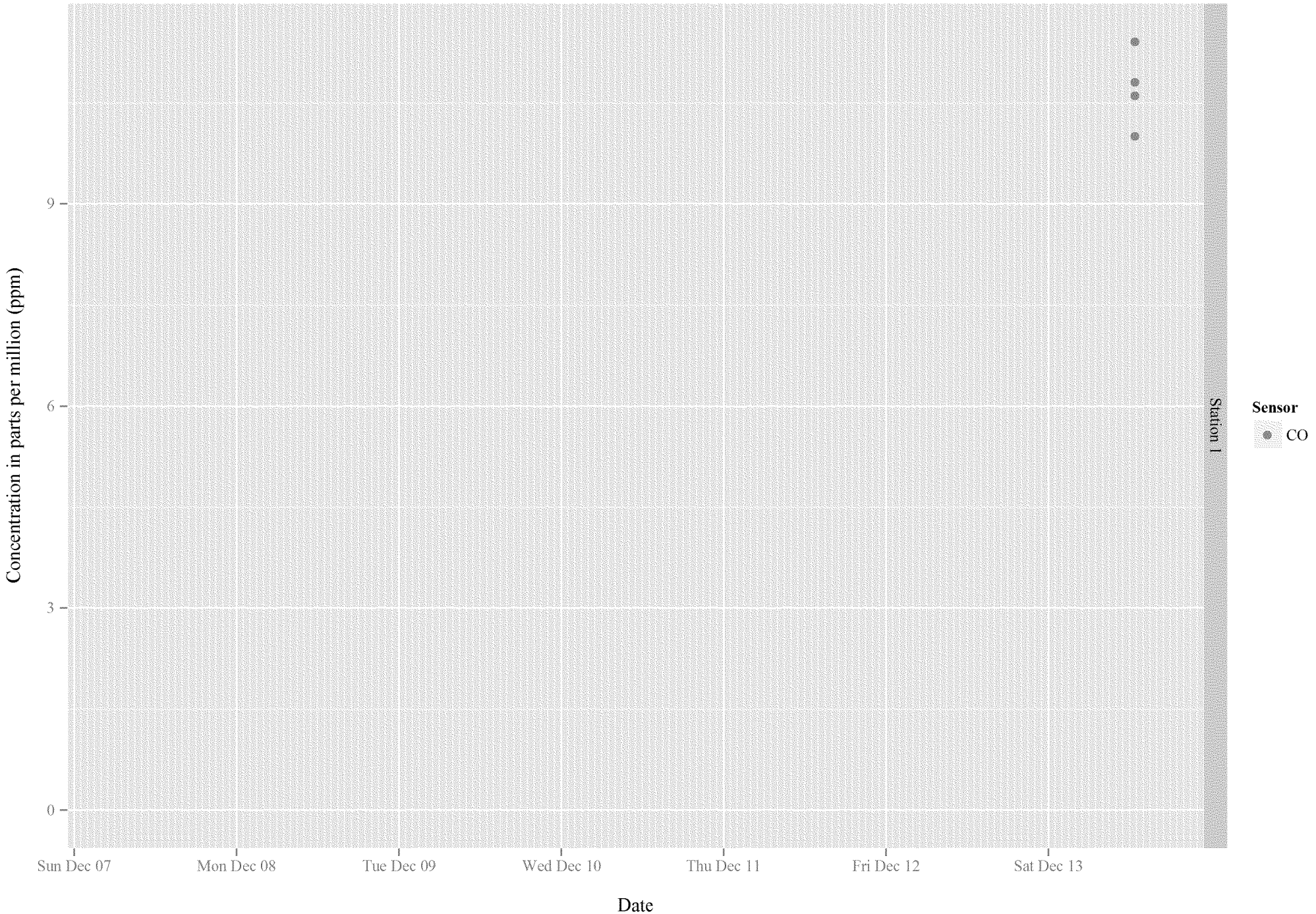

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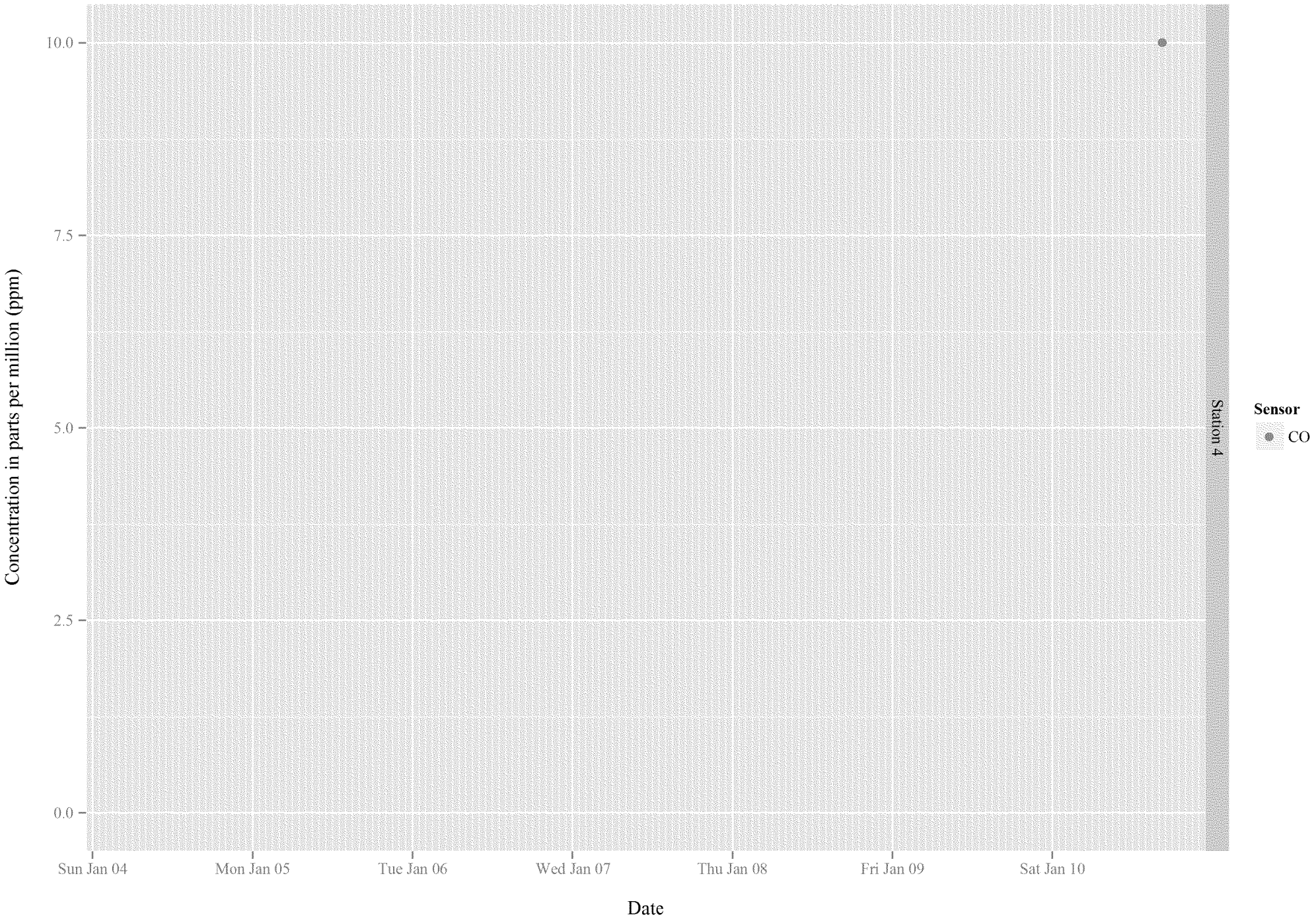

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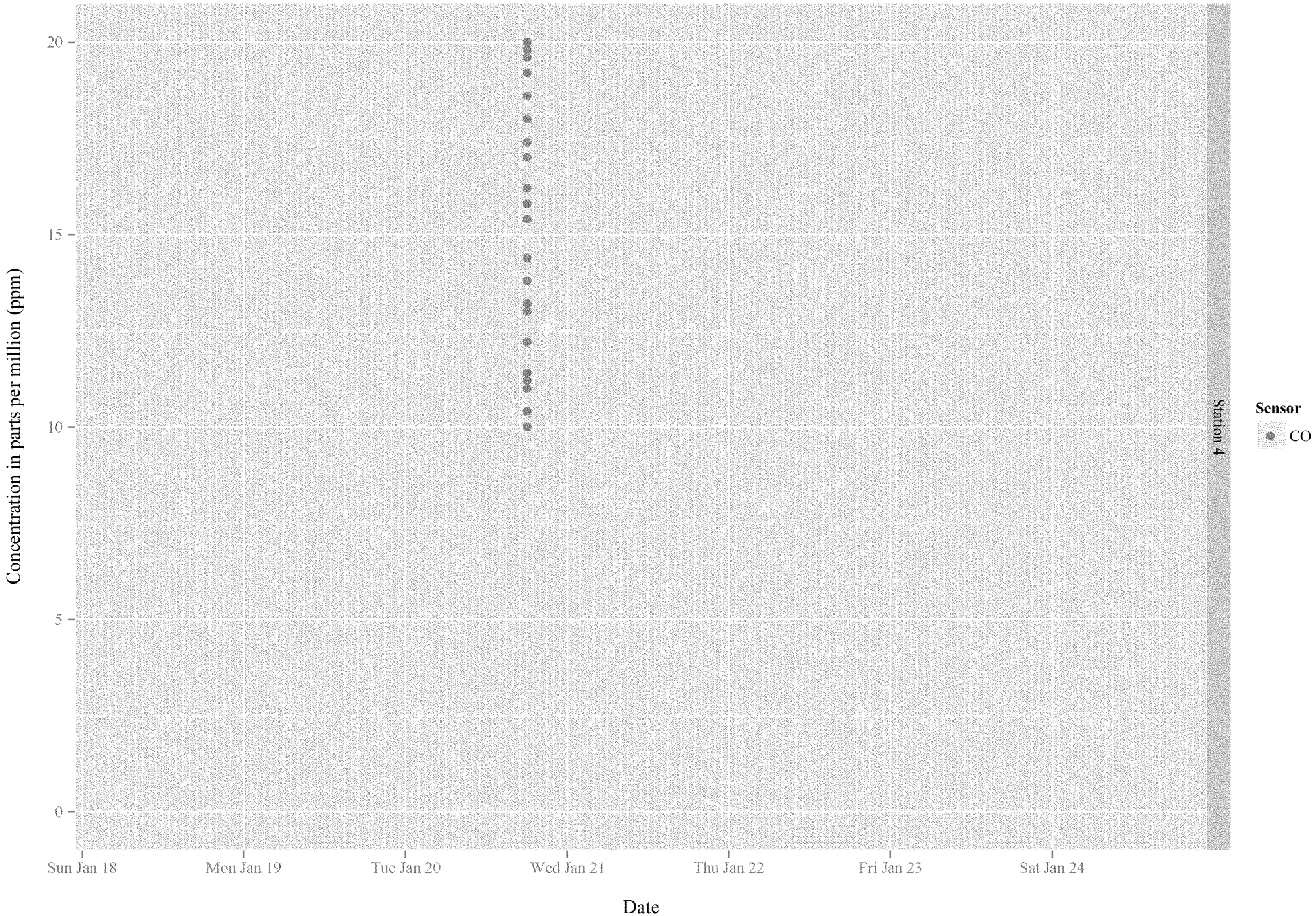
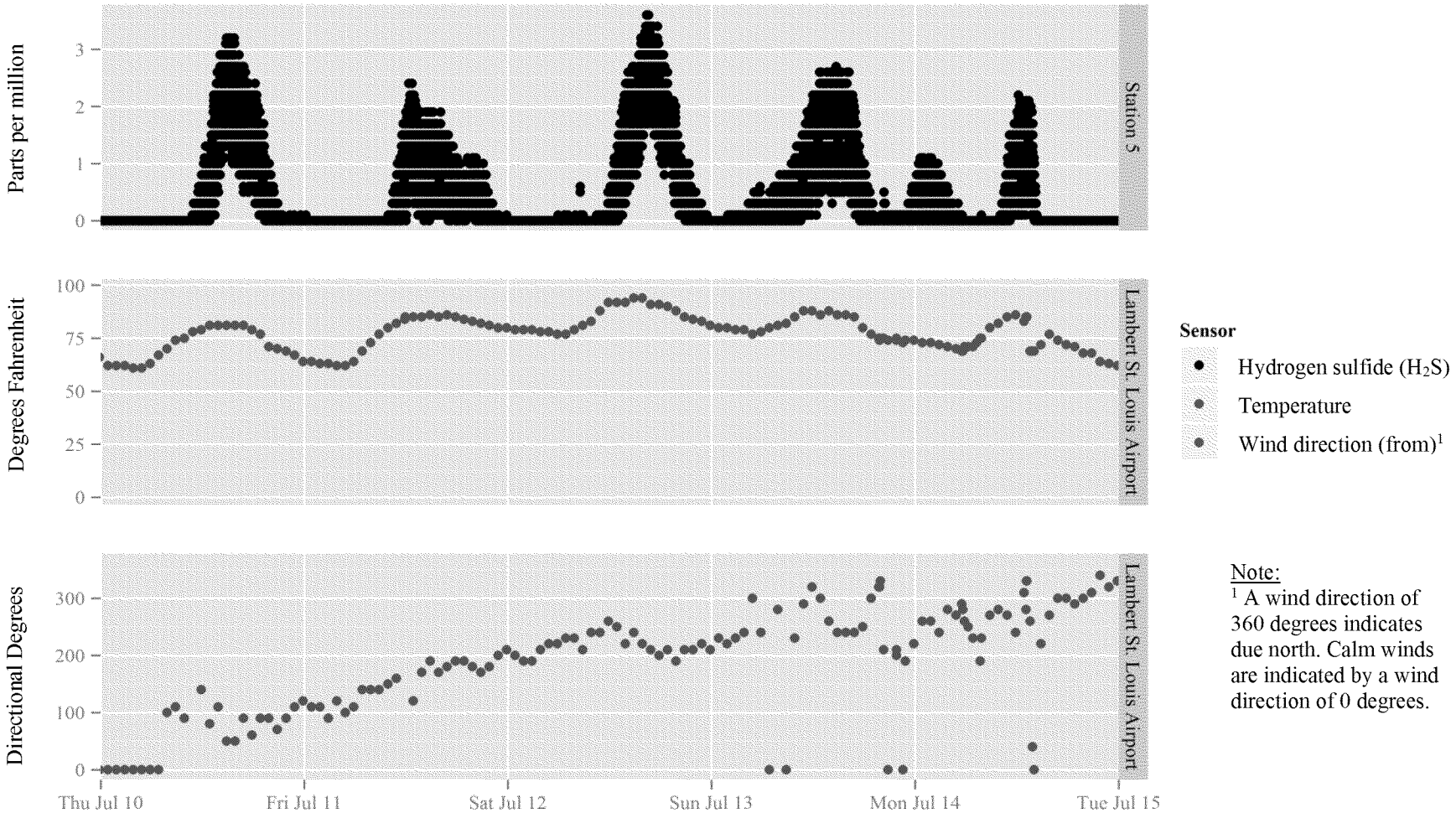


APPENDIX D

PLOT OF JULY 10 – 14, 2014 STATION 5 HYDROGEN SULFIDE MEASUREMENTS WITH TEMPERATURE AND WIND DIRECTION

EXHIBIT D-1

PLOT OF JULY 10 – 14, 2014 STATION 5 HYDROGEN SULFIDE MEASUREMENTS WITH TEMPERATURE AND WIND DIRECTION



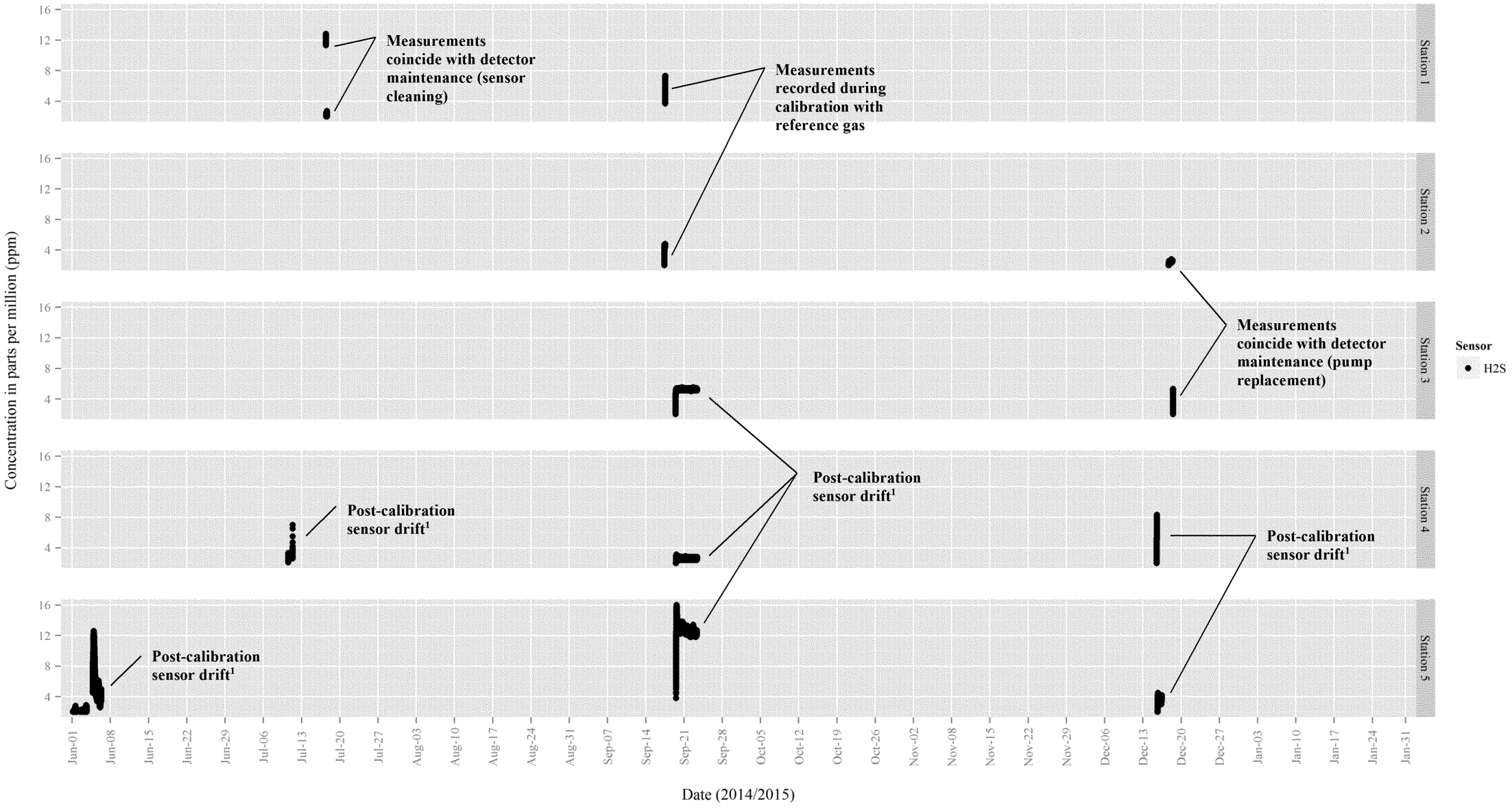
Note:
[1] A wind direction of 360 degrees indicates due north. Calm winds are indicated by a wind direction of 0 degrees.

APPENDIX E

ANNOTATED PLOT OF AREARAE MEASUREMENTS AFFECTED BY LOSS OF CALIBRATION, POLLING DURING CALIBRATION, OR OTHER INSTRUMENT ISSUES

EXHIBIT E-1

ANNOTATED PLOT OF AREARAE MEASUREMENTS AFFECTED BY LOSS OF CALIBRATION, POLLING DURING CALIBRATION, OR OTHER INSTRUMENT ISSUES



[1] Detector was found to give a response outside of acceptable control limits based on a response check or re-calibration using a reference gas standard